



## Correlation between Modified Middle Phalanx of the Middle Finger Maturation Stages and the Developmental Stages of Mandibular Second Molar for Pubertal Growth Spurt Assessment among a Group of Egyptian Females. A Cross Sectional Study

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### Abstract

**Introduction:** assessment of maturation stage is of prime importance in diagnosis and treatment planning. Our aim was to assess the time of pubertal growth spurt in a group of Egyptian females aged between 8 and 14 years old. Using modified middle phalanx of middle finger to find the correlation between MP3 maturation stages and mandibular second molar developmental stages.

**Methods:** Participants were 1740 randomly selected adolescent females from Egyptian primary and preparatory schools. Each participant's middle phalanx of the middle finger was digitally radiographed to assess her MP3 stage. Seventy eight participants from the included subjects were chosen randomly and their mandibular second molar were also digitally radiographed, recorded and assessed using Demirjian., et al. method. Data were collected and statistically analyzed.

**Results:** There was direct correlation between MP3 stages and mandibular second molar calcification stages. The mean  $\pm$  standard deviation values for age of pubertal growth spurt among a group of Egyptian adolescent females was 10.96 years  $\pm$ 1.06 years old. The mean pubertal growth spurt in the studied Egyptian females was earlier than males. Conclusions: This study suggests that there is direct correlation between MP3 stages and mandibular second molar calcification stages.

**Keywords:** Pubertal Growth; Mp3; Mandibular Second Molar Calcification Stages

### Introduction

Growth is the result of biological processes by means of which living matter normally gets larger and it is not uniform throughout life. Adolescence is a period during which the rate of growth acceleration reaches a peak velocity (pubertal growth spurt) and then decelerates until adulthood is achieved. There are marked individual variations in the initiation, duration, rate and amount of growth during this period of life [1].

One of the objectives of orthodontic treatment during adolescence, in cases with skeletal discrepancies, is to take advantage of

patient's growth changes. Maturation status can have a considerable influence on diagnosis, treatment goals, treatment planning and the eventual outcome of orthodontic treatment. This is especially true when treatment considerations are based strongly on facial growth such as the use of extra oral traction, functional appliances, selection of orthodontic retention and orthognathic surgery.

The maturity status of a child is best estimated relative to specific stages of physiologic maturity than chronological age, being not a reliable indicator. Physiological age is estimated by the maturation of one or more tissue systems. It could also be estimated by somatic, sexual, skeletal and dental maturity [2].

Skeletal maturity (or skeletal age) is frequently determined by assessing the maturational status and level of ossification of bony markers within the skeletal system. Among the various developmental indicators, skeletal age is considered the most reliable method to correlate with the general biological and physiological body maturation [3,4].

Various areas of the skeleton have been used as maturity indicators like the frontal sinus, the foot, the ankle, the hip, the elbow, the hand-wrist and the cervical vertebrae [5,6].

In orthodontics, the skeletal maturity has been assessed using either hand-wrist maturation index (HWMI) as performed by Fishman [7], which is one of the most reliable and valid maturation indicators, or cervical vertebrae maturation index (CVMI) as performed by Hassel [8] which is reliable and valid as Fishman's in addition to its availability. Lately, the middle phalanx of the third finger (MP3) was used by Hagg and Taranger [3] and modified by Rajagopale and Kansal [9] Using periapical dental radiographic films.

During the development of the teeth, their roots show the same morphological stages. Many authors described these stages, and correlated it to another growth indicator, like hand-wrist and cervical vertebrae; the tooth of interest is mandibular second molar as there is a correlation between starting its apex to calcify and other events of puberty. This can be used to indicate approaching growth spurt.

Since assessment of pubertal growth spurt age within the Egyptian female population is insufficient, the aim of this study was to assess the pubertal growth spurt in Egyptian females using modified middle phalanx of middle finger stages (Mmp3) and to study its correlation with developmental stages of mandibular second molar.

### Materials and Method Sample

The sample included in this study were 1740 Egyptian females, with an age range between 8-14 years, to ensure that they were around the circumpubertal growth period. Sample was randomly collected from total number of 88 primary and preparatory schools.

The selected sample fulfilled the following eligibility criteria Girls of Egyptian origin, with age range 8-14 years. Did not have congenital dental abnormalities, growth syndromes, malnutrition or systemic diseases.

### Methods

#### Digital Radiography of MP3

Each subject was radiographed using digital dental radiography technique of high clarity and good contrast for his MP3 (middle phalanx of 3<sup>rd</sup> left finger). For accuracy and reliability of the method, all X-rays were taken using the same machine, at the same distances (X-ray source – film and film – subject) and intensity. The X-ray was taken with a Digital Dental Portable X- Ray Machine System. Each subject was instructed to place her left hand with the palm downward on a flat table. The finger concerned was aligned with the long axis of the intra-oral dental sensor, in such a way that the area to be radiographed was located in the center of the sensor.

The cone of the dental X-ray machine was positioned in light contact with the middle phalanx of the middle finger and perpendicular to the sensor (Figure 1). The exposure time was 0.05 seconds

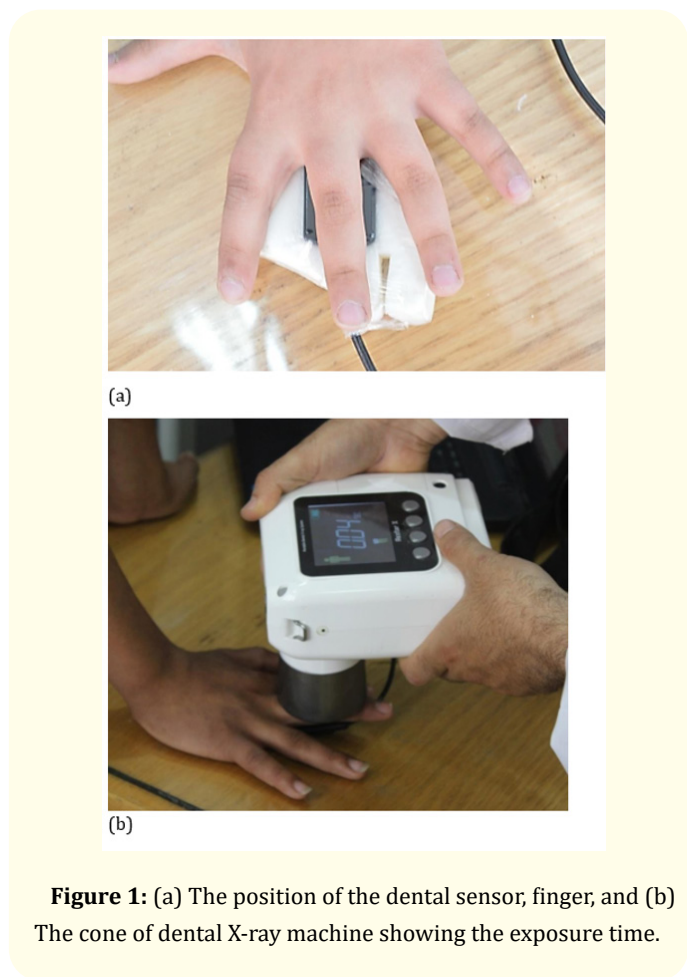
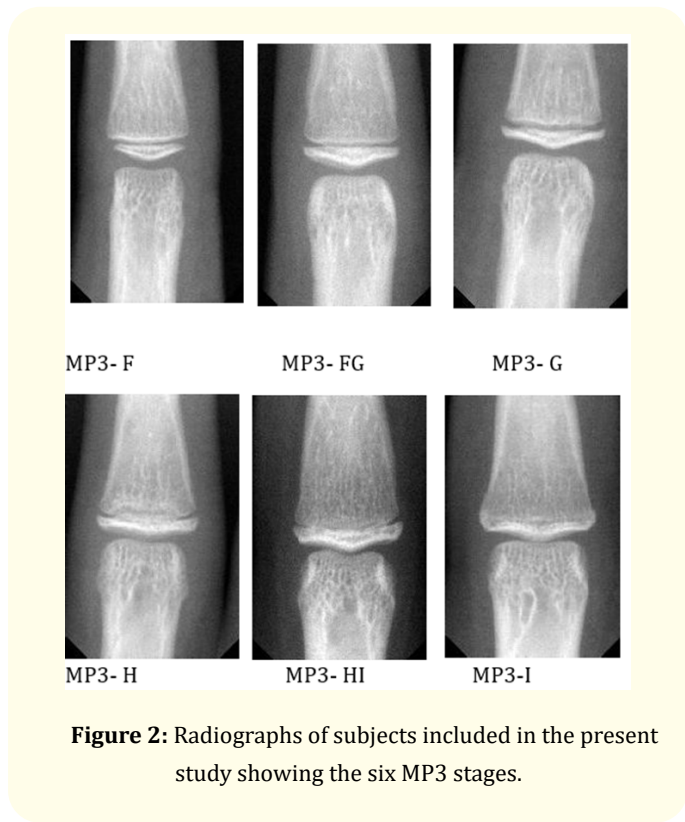


Figure 1: (a) The position of the dental sensor, finger, and (b) The cone of dental X-ray machine showing the exposure time.

**Assessment of MP3 Maturation Stages**

The developmental stage of the middle phalanx of the third finger (MP3) was evaluated for each digital radiograph according to the method described by Rajagopal and Kansal (2002) [9]. The method describes six developmental stages as shown in figures 2 and table 1.



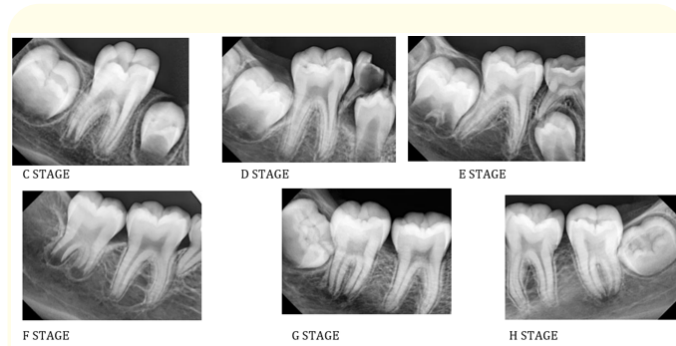
**Figure 2:** Radiographs of subjects included in the present study showing the six MP3 stages.

MP3-HI: Maturation period of PGS	Superior surface of the epiphysis shows smooth concavity whereas, Metaphysis shows smooth convex surface, almost fitting into reciprocal concavity of the epiphysis. No undulation is present in the metaphysis. Radiolucent gap between epiphysis and metaphysis is insignificant.
MP3-I: End of PGS	Fusion of the epiphysis and metaphysis is complete. No radiolucent gap exists between metaphysis and epiphysis.

**Table 1:** Characteristic of MP3 stages described by Rajagopal and Kansal with a description of events taking place during each stage.

**Assessment of Development Stage of Lower Second Molar**

- Digital periapical radiographs of high clarity and good contrast were taken for mandibular second molar.
- All the X-rays were taken by the same machine, at the same distance (X-ray source-film and film- subject distance) and intensity.
- Tooth calcification was assessed according to the Demirjian, *et al.* method in which each tooth is assigned by one of 8 calcification stages, A to H.



**Figure 3:** Six figures representing the six stages described by Demirjian, *et al.* method in which each tooth is assigned by one of 8 calcification stages, A to H.

MP3-F: Start of PGS	The epiphysis is as wide as the metaphysis. The ends of epiphysis are tapered and rounded. Metaphysis show no undulation. Wide radiolucent gap between epiphysis and metaphysis. This denotes the onset of the pubertal growth spurt.
MP3-FG Acceleration period of PGS	The epiphysis is as wide as the metaphysis. Metaphysis show beginning of undulation. Wide radiolucent gap between metaphysis and epiphysis.
MP3-G: Peak of PGS	The sides of the epiphysis are thickened and cap its metaphysis forming a sharp edge distally on one or both sides. Marked undulation in metaphysis giving it a "Cupid bow" appearance. Radiolucent gap between epiphysis and metaphysis is moderate.
MP3-H: Deceleration of PGS	Fusion of the epiphysis and metaphysis has begun. Epiphysis is beginning to narrow. Slight convexity is seen under central part of metaphysis. Radiolucent gap begins to narrow

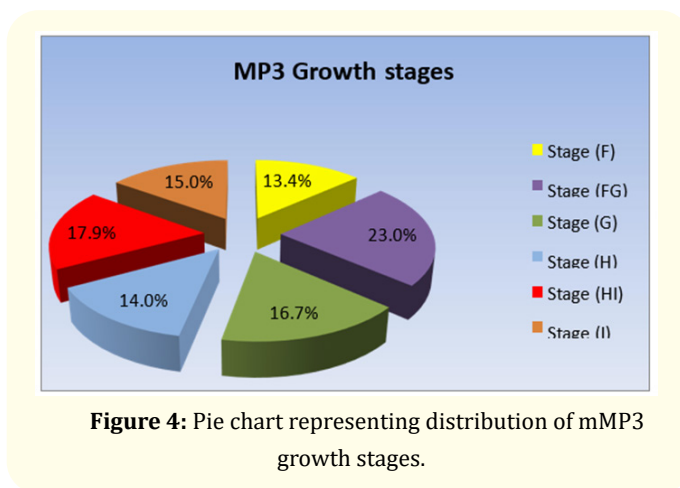
Stage C	Complete crown formation
Stage D	Complete crown formation at level of CEJ, root formation commenced.
Stage E	Root length less than crown, bifurcation commenced calcification.
Stage F	Root length equal crown height, root have distinct form.
Stage G	Wall of root canal are parallel, apex end open.
Stage H	Root formation completed and closed apex.

**Table 2:** Dental calcification stages characteristic using the Demirjian Index.

**Results**

**Distribution Modified MP3 growth stages**

Results of MP3 growth stages revealed that 234/1740 subjects (13.4%) had Stage (F), 400/1740 subjects (23%) had Stage (FG), 290/1740 subjects (16.7%) had Stage (G), 244/1740 subjects (14%) had Stage (H), 311/1740 subjects (17.9%) had Stage (HI) while 261/1740 subjects (15%) had Stage (I). The distribution of MP3 growth stages is presented in Figure (4).



**Figure 4:** Pie chart representing distribution of mMP3 growth stages.

**Comparison between mean age values at different modified MP3 growth stages**

There was a statistically significant difference between mean age values at different mMP3 growth stages. Pair-wise comparisons showed that the highest mean age was found with Stage (I). Stage (HI) showed statistically significantly lower mean value followed by Stage (H), Stage (G) then Stage (FG) with a statistically significant difference between all these stages. Stage (F) showed the statistically significantly lowest mean age. The mean and standard deviation values of pubertal spurt age were  $10.96 \pm 1.06$  years old at Stage (G).

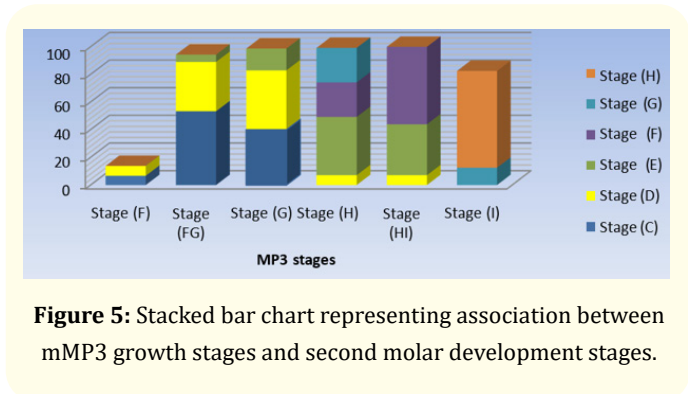
MP3 Growth stage	Mean	SD	95% CI for the mean	P-value
F (13.4%)	8.88 <sup>F</sup>	0.68	8.8-8.97	<0.001
FG (23%)	9.96 <sup>E</sup>	1.21	9.84-10.07	
G (16.7%)	10.96 <sup>D</sup>	1.06	10.74-11.08	
H (14%)	11.71 <sup>C</sup>	0.93	11.6-11.83	
HI (17.9%)	12.37 <sup>B</sup>	0.98	12.27-12.48	
I (15%)	13.04 <sup>A</sup>	0.72	12.96-13.13	

**Table 3:** Descriptive statistics and results of one-way ANOVA and Tukey’s tests for the comparison between mean age values at different mMP3 growth stages.

\*: Significant at  $P \leq 0.05$ , Different superscripts are statistically significantly different.

**Association between MP3 growth stages and second molar calcification stages**

There was a statistically significant association between modified MP3 stages and second molar calcification stages. Subjects with MP3 stage (G) showed the highest prevalence among subjects with second molar stage (D) followed by second molar stage (C) then second molar Stage (E).



**Figure 5:** Stacked bar chart representing association between mMP3 growth stages and second molar development stages.

MP3 stages	Stage (C)		Stage (D)		Stage (E)		Stage (F)		Stage (G)		Stage (H)		P-value
	n	%	n	%	n	%	n	%	n	%	n	%	
Stage (F)	1	6.7	1	7.1	0	0	0	0	0	0	0	0	
Stage (FG)	8	53.3	5	35.7	1	5.3	0	0	0	0	0	0	
Stage (G)	6	40	6	42.9	3	15.8	0	0	0	0	0	0	
Stage (H)	0	0	1	7.1	8	42.1	3	25	2	25	0	0	<0.001*
Stage (HI)	0	0	1	7.1	7	36.8	9	75	5	62.5	3	30	
Stage (I)	0	0	0	0	0	0	0	0	1	12.5	7	70	

**Table 4:** Frequencies, percentages and results of Fisher’s Exact test for the association between MP3 stages and second molar calcification stages.

\*: Significant at  $P \leq 0.05$ .

## Discussion

The mean skeletal maturity age (MP3-G stage) that represents the peak of height velocity (PHV) in Egyptian females were found to be  $10.96y \pm 1.06$  years. The result of the current study agrees with the result of Vedye., *et al*, (2008) [10]. Who assessed the pubertal growth in healthy Turkish girl's subjects with sample size close to that of the present study (1600) and similar methodology. They found that the growth spurt in Turkish occurred at age 11.4 years.

On the other hand, the mean skeletal maturity age of the present study disagrees with the study performed by Sutow [11] who assessed skeletal maturation in healthy children in Japan and compared them with Caucasians. He found that the skeletal maturation in Japanese was (13.1 years) later than Caucasians (11.9 years). This disagreement may be due to racial differences.

In addition the study performed by Kim., *et al*, (2015) [12] found that the growth spurt in Korean girls occurred at 13.1years. Growth spurt in Korean girls was found to be later than the Egyptian girls which might be due to methodological difference where they used the mandibular canine stages and could be also due to the racial difference between Egyptian and Korean.

In the present study there was a statistically significant association between modified MP3 stages and lower second molar development stages (DI). The significance level was set at  $P \leq 0.05$ .

Concerning pubertal stage (G) it showed highest distribution in DI stage D (complete crown formation which refers to the accelerating phase of growth. This finding of the present study was in disagreement with the study performed by Goyal., *et al*. (2013) [13] which studied the reliability of the calcification stages of the mandibular permanent canines and the second molars to assess the skeletal maturity level and they found MP3 Stage (G) corresponded to second molar Stage E in females.

The result of the present study concerning pre pubertal stage (F), showing highest distribution of DI stage D was in agreement with the finding of Joshi., *et al*. (2018) [14]. While FG stage of modified MP3 (indicating start of peak) was different. In the present study stage FG was in agreement with stage C of DI, while study of Joshi., *et al*. (2018) was in agreement with stage E of DI). This disagreement may be due to sample size difference and racial difference.

Regarding gender variations of skeletal maturity age, the Egyptian females in the present study tended to mature about two years earlier (10.96 years) than Egyptian males (13.64 years) at MP3-G stage as reported by Salem Awidat, (2015) [15] who conducted a study to assess the pubertal growth spurt in Egyptian Adolescents

males using middle phalanx of the middle finger in the same Egyptian schools.

## Conclusion

Based on the findings of this study, the following conclusions could be drawn

- The mean skeletal maturity age (MP3-G stage) that represents the peak of height velocity (PHV) in Egyptian females were found to be  $10.96 \text{ years} \pm 1.06$  years which was approximately 12.02 months after pre-peak stage.
- The start of the pre-peak stage (MP3-FG) of pubertal growth was reached at  $9.96 \text{ years} \pm 1.21$  years.

This means that the growth modulation treatment by functional orthodontic appliances should be done in females within range of  $9.96 \text{ years} \pm 1.21$  to  $11.71 \text{ years} \pm 0.93$  that represents the active period of pubertal growth between the pre-peak (MP3-FG) and the post-peak (MP3-H) stages respectively.

- Since there was a statistically significant association between modified MP3 (G) stage and second molar calcification stages (DI) Stage D, second molar DI stage D could be used as a maturity indicator of the pubertal growth period.

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