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Original Research Article

Peak timing of the pubertal growth spurt according to the sagittal and vertical skeletal patterns

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Abstract: The aim of this study was to evaluate the peak timing of pubertal growth spurt among individuals who have different vertical and sagittal skeletal patterns. The samples were derived from lateral cephalometric and hand-wrist radiographs of 934 subjects. Lateral cephalometric and hand-wrist radiographs of 188 (102 females, 86 males) patients who were at MP3cap stage were chosen. Subjects were divided into three groups according to the sagittal (Class I: 4°≥ ANB ≥0°, Class II: ANB >4°, Class III: 0°> ANB) and three groups to the vertical skeletal relationships (Normal facial pattern: 38°≥ SN-GoGn ≥26°, high angle: SN-GoGn > 38°, low angle: 26°> SN-GoGn). Constitutions of the groups were carried out separately with respect to the gender. Chronological ages of the groups were analyzed statistically to detect the differences in terms of the peak timing of pubertal growth spurt between the groups. No statistically significant differences were detected among the groups (P>0.05). There is no difference between the subjects who have different sagittal and vertical skeletal patterns in terms of the peak timing of the pubertal growth spurt.
Keywords: Chronological age, pubertal growth spurt, skeletal pattern

INTRODUCTION

Information about growth trends in different malocclusion types is crucial for both creating suitable treatment plan and expecting long term stable results [1]. In functional jaw orthopaedics, effectiveness of the treatment is closely related to growth trend including velocity, timing and duration of the growth [2-6]. Being aware of the end of active growth period is also critical during orthognatic or implant surgery planning. Additionally, stability of the face mask therapy in class III patients is linked to ceasing of the growth. However, growth trend at puberty is not a uniform period and it has fluctuations with accelerations and decelerations at different maturational stages [7]. And it was shown that skeletal growth patterns may have an influence on timing of growth spurt [1].

Assessments of the growth and development are basic topics in the orthodontic literature. Studies have shown that fluctuations during the growth period were managed by the complex endocrine regulation [8]. Hence, estimation of the growth potential becomes a challenge to clinicians. The most valuable method for evaluating of growth is analysis of the individual longitudinal data set [1]. However, longitudinal records related to growth and developments are rarely available and this method is not useful clinically for evaluating pubertal growth [9]. In addition to the longitudinal data set, various biological indicators have been suggested to evaluate the pubertal growth period [10-12]. Body weight, body height, menarche, secondary sexual characteristics, dental development, skeletal development and chronological age were investigated as an indicator of pubertal growth [13-15].

In the literature, chronological age has been suggested as one of the indicator of pubertal growth. It was stated that individual growth could be evaluated as average, accelerated or retarded by means of comparing with standards for age and gender [9]. However, studies investigated the relationship between chronological age and pubertal growth, revealed a weak correlation. It was concluded that growth could not be evaluated solely on the basis of the chronological age owing to the individual variations. On the other hand, the cause of the weak correlation has not been studied extensively. Individual variability was presented as the main reason of weak correlation.

The purpose of this study was to investigate that whether there is a relationship between the peak timing of the pubertal growth spurt and skeletal pattern or not.

MATERIAL AND METHODS

The present study was performed according to the World Medical Association Declaration of Helsinki. Since it had a retrospective study structure, there was no need for acquiring informed consent. This study was carried out on 934 pairs of pretreatment lateral cephalometric and hand-wrist radiographs which were taken at the same time and collected. Regardless of the skeletal classification, radiographs which had sufficient image quality were included in the study. Additionally, lateral cephalometric radiographs which did not meet adequate standards such as unclosed jaws and improperly positioned head during taking radiographs were excluded.

Greulich and Pyle [16] method was used for assessment of growth and development stages on hand-wrist radiographs. For all hand-wrist radiographs, the relationship of middle phalanx of third finger and its epiphysis was examined and capping of middle phalanx of third finger by its epiphysis (MP3cap stage) was evaluated as the peak timing of pubertal growth spurt (Fig- 1). Calcification of ulnar sesamoid was also taken into consideration to confirm the peak stage. All the radiographs evaluated according to the Greulich and Pyle method and only radiographs of the subjects who were in the MP3cap stage were included in the study. Total final sample was comprised of 188 (102 females, 86 males) pairs of pretreatment lateral cephalometric and hand-wrist radiographs which were taken at the same time.

Fig 1: A sample of evaluated as MP3cap stage.

Cephalometric Analysis

Lateral cephalometric radiographs were stored on a personal computer and Dolphin Imaging 11.5 Software (Dolphin Imaging and Management Solutions, Chatsworth, California, USA) was used to obtain the cephalometric measurements. Cephalometric tracing and analysis were done by one investigator (F.C.). Two different categories were constituted according to the sagittal and vertical skeletal pattern. Subjects were divided into three groups according to the sagittal (Class I: 4°≥ ANB ≥0°, Class II: ANB >4°, Class III: 0°> ANB) and three groups to the vertical skeletal relationships (Normal facial pattern: 38°≥ SN-GoGn ≥26°, High angle: SN-GoGn > 38°, Low angle: 26°> SN-GoGn). Constitutions of the groups were carried out separately with respect to the gender.

STATISTICAL ANALYSIS

Standard descriptive statistics (mean and standard deviation of age) were calculated for each group. The distribution of the data for each group was tested using the Kolmogorov-Smirnov test. After the normality of data set had revealed, analysis of variance (ANOVA) and independent samples t-test were used to detecting significant differences. Statistically significance was accepted at a level of $P<0.05$. Analysis was performed with a commercial social science statistical package (SPSS for Windows, version 19.0, SPSS Inc., Chicago, IL, USA).

RESULTS

The mean chronological ages of each group at which the MP3cap stage are presented in Table 1. According to the ANOVA test, there were no statistically significant differences with regard to attaining pubertal peak in both sagittal and vertical groups. Independent samples t-test was revealed that there was a sexual dimorphism in terms of attaining pubertal peak. For all groups, peak timing of the pubertal growth spurt in females takes place earlier than in males. Statistical analysis was given in Table 2.

Table 1: Evaluation of the Pubertal Peak Timing in Different Skeletal Patterns

GENDER	SKELETAL PATTERN	N	GROUP	MEAN ± SD (month)	p
MALE	SAGITTAL	32	Class I	168.41±19.67	0.898
		46	Class II	166.73±13.06	
		8	Class III	168±15.93	
	VERTICAL	56	Normal	167.73±15.29	0.486
		15	High Angle	170.44±17.66	
		15	Low Angle	163.52±16.69	
FEMALE	SAGITTAL	35	Class I	151.09±12.86	0.356
		59	Class II	147.65±13.38	
		8	Class III	145.37±10.65	
	VERTICAL	73	Normal	149.03±13.48	0.839
		20	High Angle	148.31±13.25	
		9	Low Angle	146.34±9.22	
P<0.05 ***** Statistically Significant Difference					

Table 2: Evaluation of the Gender Difference in Pubertal Peak Timing

DIRECTION	SKELETAL PATTERN	GENDER				
		MALE		FEMALE		p
		N	MEAN ± SD (month)	N	MEAN ± SD (month)	
SAGITTAL	Class I	32	168.41±19.67	35	151.09±12.86	**<0.001***
	Class II	46	166.73±13.06	59	147.65±13.38	**<0.001***
	Class III	8	168±15.93	8	145.37±10.65	**0.005***
VERTICAL	Normal	56	167.73±15.29	73	149.03±13.48	**<0.001***
	High Angle	15	170.44±17.66	20	148.31±13.25	**<0.001***
	Low Angle	15	163.52±16.69	9	146.34±9.22	**0.010***
P<0.05 ***** Statistically Significant Difference						

DISCUSSION

Growth and development of the craniofacial structure have been interested all along the modern orthodontics by the researchers. Especially with the taking place of cephalometric radiographs in the clinical practice, measurements of amount and direction of craniofacial alteration have become clearer than before. Obtaining of the longitudinal records has uncovered the mystery of the human growth and development.

The onset timing of puberty differs from person to another and varied with gender, generation, environment and population [17]. We suppose that these factors which can affect the pubertal growth timing may be determinant factors upon the sagittal and vertical skeletal type. Hereby, it can be detected a relationship between the pubertal growth timing and sagittal or vertical skeletal type. It has been already stated that there was a difference in duration of the pubertal growth spurt between the skeletal class III and class I subjects. Pubertal growth spurt period in class III subjects was longer than in class I subjects and it was concluded that the larger mandibular length in class III patients might be related to the longer duration of the pubertal growth spurt period [13]. Furthermore, Reyes *et al.;* [1] showed that pubertal growth spurt in class III malocclusion starts later and greatest increase in mandibular length is occurred one year later in both female and male subjects when compared with normal occlusion. Likewise, Battagel [18] has also provided data about delayed pubertal growth spurt including mandibular dimensions in class III subjects. However, there is no information about data of the peak timing of pubertal growth spurt according to the sagittal and vertical skeletal classification, excluding class III patients in the literature.

In the present study, we have attempted for the first time to elucidate that whether there is any difference between the peak timing of pubertal growth spurt in different growth trends. Greulich and Pyle method was used to assessment on the hand-wrist radiographs and MP3cap stage was considered as the peak stage of pubertal growth [16].

Results showed that, there was no statistically significant difference in chronological age in terms of pubertal peak between the groups which consisted according to sagittal and vertical skeletal pattern. This finding is not in agreement with the results of Kuc-Michalska and Baccetti [13] and Reyes *et al.*[1]. It was reported that, although the onset timing of pubertal

growth spurt is similar in class I and class III subjects, the duration of pubertal peak lasts 11 months in class I, 16 months in class III participants[13]. They interpret the excessive mandibular length in class III in the light of this information.

It may be mentioned that, methodological differences could cause these conflicting results. We used hand-wrist radiographs and MP3cap stage was accepted as maximum pubertal growth, whereas, Kuc-Michalska and Baccetti used cervical vertebrae maturation (CVM) method performed on the lateral cephalometric radiographs. While we have tried to detect only peak point of pubertal growth, they have investigated the whole duration of puberty by means of cross-sectional data derived from different subjects. Furthermore, we believe that cross-sectional data cannot elucidate true longitudinal changes, even if it consists of great sample size.

Although the increased popularity of CVM assessment as an alternative method for the hand-wrist radiographs in recent years, reliability of this method still has been controversial issue. Sohrabi *et al.;* [19] stated that difficulty in determining the C3 and C4 vertebrae morphology leads to poor reproducibility of the CVM. Engel *et al.;* [20] could not find any evidence to support the hypothesis that the CVM method can predict the amount of craniofacial growth in girls with Class II malocclusion. Likewise, it was stated that CVM method cannot replace other radiographic evaluations and concluded that cervical vertebrae evaluation offers no advantage over chronologic age in either assessing skeletal age or predicting the pubertal growth spurt [2]. We assume that the assessment of the hand-wrist radiograph is more valuable than CVM method for evaluating of growth and development.

Reyes *et al.;* [1] also stated that the interval of largest increase in mandibular length occurred on average 1 year later in both female and male Class III patients with respect to subjects with normal occlusion. Although hand-wrist radiograph is a useful tool for evaluating the pubertal growth spurt, all parts of the body may not follow the somatic growth trend. In class III subjects, timing of largest increase in mandibular length may not coincide with the MP3cap stage. The literature provides abundant studies which investigated the relationship between the hand-wrist morphology and mandibular growth pattern in class II, but there is a scarcity for class III subjects.

Another possible reason of this conflict result may be the number of class III subjects in the present study. Class III malocclusion has already relatively low prevalence, especially in Caucasian populations. In addition to that, class III patients are well recognized by the public and guided to the orthodontists in early interventions by their parents [1]. Because of all these reasons, we had difficulty in finding untreated class III patient who was in MP3cap stage. In the final sample which was consisted of 188 subjects, there were only 16 untreated class III subjects (8 females, 8 males).

CONCLUSION

1. In terms of the peak timing of pubertal growth spurt, there is no difference among the groups which were constituted according to the sagittal and vertical skeletal pattern.
2. There is sexual dimorphism with regard to timing of the puberty. For all groups, pubertal growth spurt in female's takes place earlier than in males.

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