Pubertal Growth Spurt Peak in Angle Class I and II Malocclusions Using Cervical Vertebrae Maturation Analysis in Deutero-Malay Children

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ORIGINAL ARTICLE

Pubertal Growth Spurt Peak in Angle Class I and II Malocclusions Using Cervical Vertebrae Maturation Analysis in Deutero-Malay Children

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ABSTRACT

Background. The incidence rate of Angle Class I and Class II malocclusions in mixed dentition is higher than Class III. In orthodontic interceptive treatment, it is necessary to identify pubertal growth spurt peak individually because the best growth modification could be obtained during this period. One of the methods in assessing the pubertal growth spurt peak is cervical vertebrae maturation (CVM), which is done using a lateral cephalometric radiograph. CVM evaluates potential growth and skeletal maturity by assessing cervical vertebrae anatomy. Identifying the duration of growth spurt peak on both malocclusion classes is the most pivotal aspect of optimizing remodeling and correction of children's malocclusion.

Objective. Distinguishing the duration of pubertal growth spurt peak of children with Angle Class I and II malocclusions based on CVM analysis in Deutero-Malay children so that it can be used in determining optimal orthodontic treatment plan and timing in children with Class I and Angle II malocclusion for Deutero-Malay children.

Methods. Analytical observational with cross-sectional approach was applied using lateral cephalometric radiographic images from patients' medical records attending or had attended orthodontic treatment in the Pediatric Dentistry Clinic, Airlangga University Dental Hospital, Surabaya, Indonesia, in 2014-2019 that met the inclusion criteria and were analyzed with Baccetti's method of CVM analysis. This study involved 66 conventional lateral cephalometric photographs that were selected using total sampling. The data were analyzed using Independent T-Test and Mann-Whitney U Test.

Result. The duration of pubertal growth spurt peak in Angle Class I and II malocclusions was 11 and 7 months, respectively. The age of onset for Class I with CS3 was 9 years and 5 months, while for Angle Class II malocclusion starts entering the stage at 10 years 3 months of age, while for CS4 skeletal maturity we found that the age of onset for subjects with Angle Class I and II were 11 years 2 months and 12 years 4 months, respectively. The average duration of the pubertal growth spurt peak in female and male patients was 11.3 months and 18.2 months, respectively. All of these results were statistically significant ($p \leq 0.001$) and representative of the population, in this case, Deutero-Malays.

Conclusion. Four-month differences in the duration of pubertal growth spurt peak of children with Angle Class I and II were found. This may lead to a shorter treatment duration of 4 months in children with Angle Class II malocclusion when compared to children with Angle Class I malocclusion. Angle Class II malocclusion exhibit shorter pubertal growth spurt peak duration, which may account for the difference in mandibular growth on the two malocclusion classes.

Keywords: Puberty, Malocclusion, Angle Class I, Angle Class II, Cervical Vertebrae, Skeletal Age Measurement, Cephalometry, Asiatic Race, Age of Onset

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INTRODUCTION

Human growth and development are different from one another, including skeletal growth during the pubertal growth spurt period.[1] It consists of a growth spurt period where the acceleration of growth occurs and is followed by a slower growth period. Individual identification of the growth spurt period is crucial in orthodontic treatment because the best growth modification could be obtained during the pubertal growth spurt period, a period where different facial bones grew at an optimum level, thus optimizing the treatment results.[2]

Malocclusion, defined as dental misalignment or abnormal occlusion between upper and lower teeth, significantly affects craniofacial growth, oral health and its function, and patients' aesthetic appearance. In severe cases, it damages patients' systemic health.[3] Both in mixed and permanent dentition stages, Angle Class I malocclusion presents the highest incidence rate than Class II, whereas Class III presents the lowest incidence rate. The global distribution for Class I, Class II, and Class III Angle malocclusions in the mixed dentition phase were 72.74%, 23.11%, and 3.98%, respectively.[4]

One way to assess the pubertal growth spurt is by determining the maturity and evaluating the craniofacial growth potential. Frequently used diagnostic equipment nowadays evaluates morphological changes in cervical vertebrae during the skeletal maturation stage.[5] Cervical Vertebrae Maturation (CVM) method was first described by Lamparski (1972), which was then improved by Baccetti et al. in 2005. CVM currently becomes popular and is the most used diagnostic tool for growth spurt determination because the skeletal maturity analysis is done using a lateral cephalometric radiograph, a radiograph regularly needed for orthodontic diagnosis. It may lower the effect of radiation exposure and is more cost-effective because patients do not need to pay additional costs.[6,7] Gu and McNamara's and Perinetti et al.'s longitudinal study reported a maximum increase in mandibular growth occurs between Cervical Stage 3 (CS3) and Cervical Stage 4 (CS4). The age interval between these two stages is viewed as the duration of the pubertal growth spurt peak.[2] Criteria for CS3 is if the concavities at the lower borders of C2, C3, and C4 are present. C3 and C4 are rectangular horizontals in shape. The peak in mandibular growth has occurred one or two years before this stage. Criteria for CS4 is if Concavities at the lower borders of C2, C3, and C4 are seen, and at least one of the bodies of C3 and C4 is square; if not, the bodies of the remaining cervical vertebrae are still rectangular horizontal in shape. The peak of mandibular growth has occurred no more than one year before this stage.[8]

Distinguishing the duration of pubertal growth spurt peak in two of the most commonly found malocclusion classes in mixed dentition, namely Class I and II Angle, which also still rarely found in present studies, is very important to determine the correct treatment planning of orthodontic patients because facial bone growth and periods of intense or accelerated physiological growth should be analyzed individually to maximize remodeling and better correction. This study also focuses on the Deutero-Malays for it is the majority population on the island of Java, where we conducted this study, and the Deutero-Malays are also still rarely being involved in the duration of the growth spurt peak studies.

MATERIALS AND METHODS

This cross-sectional and analytical observational study involved lateral cephalometric radiographs from patients' medical records at the Pediatric Dentistry Clinic of Dental and Oral Hospital of UNAIR, Surabaya, Indonesia, from the year 2014-2019 who meet the sample inclusion criteria. This study involved 66 conventional lateral cephalometric photographs that were selected using total sampling. Deutero-Malay Race was determined by looking at the ethnicity and domicile information of subjects from their medical records. The study design was approved by the Faculty of Dental Medicine, Universitas Airlangga Health Research Ethical Clearance Commission, certificate No: 125/HRECC.FODM/III/2020.

Procedure

The following inclusion criteria implemented in this study were: 1) Deutero-Malay children age 9-17 years old (during the taken of lateral cephalometric) and have good quality conventional lateral cephalometric photographs; 2) Never underwent an orthodontic treatment before; 3) Never experienced facial trauma or surgery to facial structures; 4) Did not have congenital dental abnormalities, growth syndrome or anomaly of facial structures; 5) Conventional cephalometric photographs was in the CS3 or CS4 based on the CVM analysis.[5] The age interval between these two stages was considered to be the duration of the pubertal growth spurt peak.

Table 1. Inclusion Criteria for Angle Class I and II Malocclusions

Angle Class I Malocclusion	Angle Class II Malocclusion
Bilateral Class I molar relation	Bilateral Class II molar relation
ANB 2° ± 2° according to Steiner	ANB > 5° according to Steiner
FMA 25° ± 3°	FMA > 29°

Later, the cephalometric radiographs tracing was performed manually by authors using acetate paper to group subjects into each type of malocclusion and gender, and patients' chronological age was recorded, which was then converted into a decimal for further use in statistical analysis.

Measurements started by assessing the age of onset of CVM by their malocclusion types and compare the mean ages between these groups:

a. Angle Class I malocclusion with CS 3 skeletal maturity phase group vs Angle Class II malocclusion with CS 3 skeletal maturity phase group
b. Angle Class I malocclusion with CS 4 skeletal maturity phase group vs Angle Class II malocclusion with CS 4 skeletal maturity group

Duration of the pubertal growth spurt peak is the amount of time required from CS3 to CS4. Therefore, we calculated the mean duration of the pubertal growth spurt peak in Angle Class I and II malocclusion by comparing the mean age in each of the four sample groups. The four sample groups were:

a. Angle Class I malocclusion with CS 3 group
b. Angle Class I malocclusion with CS 4 group
c. Angle Class II malocclusion with CS 3 group
d. Angle Class II malocclusion with CS 4 group

Then to obtain the duration of the pubertal growth spurt peak between malocclusion types, we counted the amount of time required from:

a. Angle Class I malocclusion with CS 3 to CS 4
b. Angle Class II malocclusion with CS 3 to CS 4

Lastly, we did the same calculation in the gender group to obtain the duration of the pubertal growth spurt peak in males and females. The data collected was then subjected to statistical testing using SPSS ver.25 for Windows and were analyzed using Independent T-Test and Mann-Whitney U Test.

RESULT

The results for age of onset and pubertal growth spurt peak between the two malocclusions were analyzed using Independent T-Test (Tables 2 and 4). The age of onset for Class I with CS3 was 9 years and 5 months, while for Angle Class II malocclusion with the same skeletal maturity stage starts entering the stage at 10 years 3 months age and ending the stage at 13 years 8 months. In CS4 we found that the age of onset for subjects with Angle Class I and II was 11 years 2 months and 12 years 4 months, respectively. Grounding on the data above, the average age of subjects with Angle Class I malocclusion with CS3 was 11 years and 10 months (n=26). Meanwhile, the average age of subjects with Angle Class II malocclusion with the same skeletal maturity stage was 11 years and 8 months (n=9). A statistically significant difference ($p < 0.001$) was found in that difference. Moreover, a significant difference was also found in subjects with Angle Class I and Class II malocclusion with CS4 skeletal maturity, where the former (n=21) exhibited 12 years and 9 months while the latter (n=10) exhibited 12 years and 4 months (Table 3).

As shown in Table 5, subjects with Angle Class I malocclusion exhibited a peak duration of pubertal growth spurt by 11 months, while those with Angle Class II exhibited only 7 months. These 4-month differences between both malocclusion groups were statistically significant ($p < 0.001$) and representative of the population, in this case, Deutero-Malays, because the duration of the pubertal growth spurt peak was between the initial and the final value of the confidence interval. The data shown in Tables 1 and 2 used the parametric statistical method of the independent T-Test.

Gender differences in the duration of the pubertal growth spurt peak were statistically significant ($p < 0.001$)

Table 2. Independent T-Test Statistic Values for Age of Onset

Cervical Vertebral Stage	Angle Malocclusion	T-Test for Equality of Means			
		n	Sig. (2-tailed)	Mean Difference	Std. Error Difference
CS3	Class I	26	<.001	.1089934	.7196851
	Class II	9	.000	.1089934	.6492485
CS4	Class I	21	<.001	.4096885	.7860058
	Class II	10	.000	.4096885	.8093984

Table 3. Age of Onset in Angle Class I and II Malocclusion

Cervical Vertebral Stage	Angle Maloc-clusion	Age				
		n	Mean Difference	Min	Max	*p*
CS3	Class I	26	11.85 (11y 10m)	9.49 (9y 5m)	14.90 (14y 10m)	< 0.001
	Class II	9	11.74 (11y 8m)	10.27 (10y 3m)	13.69 (13y 8m)	
CS4	Class I	21	12.77 (12y 9m)	11.23 (11y 2m)	16.63 (16y 7m)	< 0.001
	Class II	10	12.36 (12y 4m)	10.58 (10y 6m)	14.95 (14y 11m)	

**n = 66; Independent T-Test ($p < 0.05$)*

Table 4. Independent T-Test Statistic Values for Pubertal Growth Spurt Peak in Angle Class I and II Malocclusion

Angle Malocclusion	Cervical Vertebral Stage	T-Test for Equality of Means			
		n	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Class I	CS3	26	<.001	-.9198251	.5766055
	CS4	21	<.001	-.9198251	.5781964
Class II	CS3	9	<.001	-.6191299	.8763020
	CS4	10	<.001	-.6191299	.8615906

Table 5. Mean Duration of the Pubertal Growth Spurt Peak in Angle Class I and II Malocclusion

Angle Maloc-clusion	Cervical Vertebral Stage		Duration of pubertal growth spurt peak	CI Limit Inferior	CI Limit Superior	*p*-value
	CS3	CS4	CS3 - CS4			
Class I	11.85	12.77	0.92 (11m)	0.18	1.34	< 0.001
Class II	11.74	12.36	0.62 (7m)	-0.42	1.20	< 0.001

**n = 66; CI: Confidence Interval; Independent T-Test ($p < 0.05$)*

Table 6. Mean Duration of the Pubertal Growth Spurt Peak I in Each Gender

Gender	Cervical Vertebral Stage		Duration of pubertal growth spurt peak	CI Limit Inferior	CI Limit Superior	*p*-value
	CS3	CS4	CS3 - CS4			
Male	12.08	13.60	1.52 (18.2m)	1.44	2.68	< 0.001
Female	10.48	11.42	0.94 (11.3m)	0.33	1.44	< 0.001

*n = 66; CI: Confidence Interval; Mann-Whitney U Test (p < 0.05)

and representative of the population. The average duration of the pubertal growth spurt peak in female and male patients was 11.3 months and 18.2 months, respectively. The non-parametric statistical method of the Mann-Whitney U test was applied (Table 6) because the data were not normally distributed.

DISCUSSION

The present study determined the onset age and pubertal growth spurt peak duration of two Angle Class malocclusions, namely Class I and Class II, using Bacetti et al.'s CVM on Deutero-Malays. This method was used because it exhibited interval growth of CVM and the pubertal peak of mandibular growth and body height.[6] Khoja et al., reported that CS3 is the appropriate skeletal maturity to begin orthodontic treatment using functional equipment because the peak of mandibular growth emerges at the same years of the beginning of CS3.[7] Age onset of CS3 skeletal maturity of subjects with Angle Class I and II malocclusion found in the present study was different from that in previous studies. The average age in the present study was 11 years and 5 months for both malocclusion Classes. This difference may be accounted for by factors influencing the pubertal growth spurt peak, such as gender, genetics, ethnicity, nutrition, and socio-economic status, in addition to the patients' age.[6,9]

Baccetti et al. applied the CVM method, where the pubertal growth spurt peak occurs during CS3 and CS4 periods. Following the age onset of CS4 found in the present study, subjects with Angle Class II malocclusion tends to enter the peak earlier than those with Angle Class I does. This can be seen by comparing the average age onset of each Angle malocclusion when entering CS3 and CS4 maturation phases. Evaluating 391 children's cephalometry, Armond et al. found that subjects with Angle Class II are more possible to enter the pubertal growth spurt twice as fast as those with Angle Class I malocclusion.[2,10]

Furthermore, the pubertal growth spurt peak duration of Angle Class I and II in the present study were in line with previous studies stating that the pubertal growth spurt peak duration of Class III is longer than that of Class I, while Class II malocclusion was found to have the shortest duration among the three Angle Class malocclusions.[2,5,9] The difference found in the present study was 4 months, this is consistent with the previous study reported by Jeelani et al. who found that subjects with Angle Class II malocclusion exhibited a shorter duration of 4.2 months than those with Angle Class I malocclusion did. The result of the study also supports Salazar-Lazo et al.'s study that found a 4-months difference between these two malocclusions Classes.[2,5]

Grounded on this information, it could be concluded that the pubertal growth spurt peak duration of Class II malocclusion is shorter, meaning that the treatment to optimize the mandibular growth potential is also shorter in time. This may also account for a shorter mandibular growth found in subjects with Angle Class II, compared to those with Class I. Longer duration of pubertal growth spurt peak may be associated with the larger size of the mandible. Meanwhile, shorter duration results in slower mandible expansion and thus leads to the smaller mandible.[2,5]

The present study also found a significant 7-months difference in pubertal growth spurt peak between male and female subjects in the present study. Modern lifestyle, including diet, physical activity, and chemical exposure are reported to serve as factors contributing to the pubertal phase.[11] These variables interact and affect pubertal growth and maturity in a complex way. Diet or nutrition factor is closely related to economic and social factors. Overweight and obesity also significantly affect pubertal growth because they affect the children's food intake and activity, which further affects the endocrine system, a complex system controlling and modifying pubertal growth.[9,11-12]

The onset, duration, and completion of pubertal growth spurt will affect the growth of mandible, a relevant aspect of dentofacial orthopedics, because the result and the stability of the treatment may be affected by patients' maturation status. Existing bodies of literature consistently prove that the length of mandibular anteroposterior and maxillo-mandibular relations are positively associated with longer pubertal growth spurt peak duration. Individuals with a longer duration of pubertal growth spurt peak may exhibit longer mandibular anteroposterior, compared to those with shorter duration. This may skeletally worsen individuals' malocclusion.[2,13]

One of the most pivotal factors in orthodontic treatment is the patients' potential growth, which is determined using the patients' chronological age, behavior age, biological age, self-concept age, and mental age. CVM method exhibits a high correlation with individuals' skeletal maturation and is highly valid in assessing the skeletal maturation during the pubertal growth period and detect the pubertal growth spurt peak, namely the duration between CS3 and CS4. Based on the position of the mandible with cervical vertebrae, mandibular morphogenesis is more similar to cervical vertebrae morphogenesis than to hand and wrist bones. Thus, the length of the mandible may closely be related to the cervical vertebrae maturation.[8,14] hand-wrist radiograph has been widely used as a reliable analysis for determining the skeletal age, a part of the assessment for individual's biological age. However, this method requires

additional radiation exposure when it is used in orthodontic treatment. The validity of Bacetti's CVM method on lateral cephalogram is equal to that of hand-wrist analysis. However, the advantage is that CVM analysis uses radiographic images that have been regularly used in orthodontic treatment, resulting in lower radiation exposure.[8,12,14-15]

In growth and development studies, longitudinal studies are the primary method for evaluating craniofacial growth. Gu & McNamara conducted a longitudinal study of 20 subjects in which cervical vertebral maturation was observed from CS 1 to CS 6 consecutively. There is a limitation in obtaining a sufficiently large sample size due to the associated increase in the number of radiographic exposures, which tends to make this methodology difficult.[5,11,15] Accordingly, cross-sectional design was applied in the present study. The subjects were matched following the Angle malocclusion Class and gender.

Finding out the age of onset and duration of pubertal growth spurt peak on Angle Class I and II malocclusion may provide a better understanding of the differences in the growth of these two types of malocclusion. It may facilitate a timely functional orthodontic treatment during this growth spurt period. Individual analysis of intensive facial bone growth and physiological growth is necessary to obtain better remodeling and correction. Besides, skeletal maturity analysis on lateral cephalometric radiographs, i.e., a type of radiograph required for orthodontic diagnosis, may decrease the radiation exposure impact; which also allows better-cost-effectiveness since patients do not need to spend additional costs.[2,6,15]

CONCLUSION

Based on CVM analysis on Deutero-Malay children, 4-month differences in the duration of the pubertal growth spurt peak of children with Angle Class I and II were found. The duration was 11 and 7 months in Angle Class I and II malocclusion, respectively. Angle Class II malocclusion exhibit a shorter duration of pubertal growth spurt peak, which may account for the differences in mandibular growth between the two malocclusion Classes. Grounded by this information, we can conclude that functional orthodontic treatment to maximize mandibular growth can be started 1-2 months earlier in children with Angle Class II malocclusion with a treatment duration of 4 months shorter when compared to children with Class I Angle malocclusion.

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Statement of Authorship

All authors participated in data collection and analysis, and approved the final version submitted.

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