THE RELATIONSHIPS BETWEEN CERVICAL VERTEBRAL MATURATION AND DENTAL CALCIFICATION AMONG MALAYS

by

AHMAD SALIM NASSAR

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C2	Second cervical vertebrae
C3	Third cervical vertebrae
C4	Fourth cervical vertebrae
CVM	Cervical vertebral maturation
CVMI	Cervical vertebral maturational index
CVMS	Cervical vertebral maturation stage
HUSM	Hospital Universiti Sains Malaysia
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences.

HUBUNGAN ANTARA PERINGKAT KEMATANGAN VERTEBRA SERVIKAL DAN KALSIFIKASI GIGI DI KALANGAN ORANG MELAYU

ABSTRAK

Kajian kematangan skeletal adalah penting dalam rawatan ortodontik. Kaedah permatangan vertebra servikal terbukti sebagai satu kaedah yang efektif dalam membuat penilaian pemecutan pertumbuhan remaja bagi setiap pesakit. Tahap kalsifikasi pergigian dicadangkan sebagai satu kaedah yang boleh dipercaya untuk menentukan kematangan gigi. Jika satu perkaitan yang kuat wujud antara kematangan vertebra servikal dengan tahap kalsifikasi pergigian antara orang Melayu, tahap kalsifikasi pergigian boleh digunakan sebagai alat diagnosis tahap satu untuk menilai kematangan skeletal di kalangan orang Melayu. Tujuan kajian ini dijalankan ialah untuk menentukan kronologi umur tahap kematangan vertebra servikal tahap kalsifikasi dan kanin mandibular kiri, premolar petama dan kedua, dan molar antara pesakit Melayu perempuan dan lelaki. Ia juga bertujuan untuk melihat hubungan antara tahap kematangan vertebra servikal dan kanin mandibular kiri, premolar pertama dan kedua, dan tahap kalsifikasi molar kedua di kalangan pesakit Melayu perempuan dan lelaki. Kajian ini adalah kajian lintang yang melibatkan seramai 215 subjek orang Melayu yang terdiri daripada 92 orang lelaki (umur antara 10-17 tahun) dan seramai 123 orang subjek perempuan (umur antara 8-15 tahun). Kaedah Baccetti et.al (2002) yang menggunakan selafogram lateral digunakan untuk menilai tahap –tahap kematangan vertebra servikal. Tahap-tahap kalsifikasi pergigian dinilai daripada radiograf ortopantomogram mengikut kaedah yang digunakan oleh Demirjian et.al (1973). Susunan kedudukan pekali kolerasi Spearman pula digunakan untuk menilai hubungan kematangan antara vertebra

servikal dengan gigi. Taburan peratusan gigi yang dikaji juga dikira untuk memahami dengan lebih jelas hubungan indeks kematangan vertebra servikal dengan umur gigi. Purata dan sishan piawai punya umur dalam tahun untuk peringkat kematangan vertebra servikal daripada, CVMS1 ke CVMSV ialah, untuk lelaki 10.92 (SD0.55), 13.11 (SD1.41), 15.32 (SD1.08), 16.38 (SD0.51), dan16.52 (SD0.42), untuk perempuan 9.77 (SD1.27), 11.14 (SD1.67), 13.17 (SD1.01), 14.30 (SD0.65), dan 14.53 (SD0.23). Purata dan sishan piawai punya peringkat kalsifikasi H untuk kiri, premolar pertama dan kedua, dan molar kedua ialah lelaki 15.05 (SD1.69), 15.18 (SD 1.58), 15.25 (SD 1.59), dan 15.95 (SD 1.01), perempuan 13.31 (SD 1.32), 13.45 (SD 1.25), 13.54 (SD 1.22), dan14.06 (SD 0.77).Pekali kolerasi antara kematangan vertebra servikal dengan tahap kalsifikasi gigi adalah signifikan secara statistik dengan julat 0.682 ke 0.772 untuk lelaki dan 0.543 ke 0.727 untuk perempuan. Bagi semua subjek lelaki dan perempuan, urutan korelasi dari terendah ke yang paling tinggi adalah kanin, premolar pertama, premolar kedua, dan molar kedua. Kebanyakan pesakit lelaki (81.5%), dan perempuan (88.2%) tidak habis peringkat kalsifikasi H di CVMS II. Ini menunjukkan bahawa kematangan vertebra servikal dengan tahap kalsifikasi gigi di kalangan orang Melayu memang mempunyai hubung kait. Ini juga mencadangkan bahawa tahap kalsifikasi gigi mungkin boleh digunakan sebagai alat klinikal pertama untuk menentukan kematangan skeletal bagi pesakit Melayu. Namun begitu, kajian lanjut disyorkan untuk sampel yang lebih besar pada masa hadapan.

THE RELATIONSHIPS BETWEEN CERVICAL VERTEBRAL MATURATION AND DENTAL CALCIFICATION AMONG MALAYS

ABSTRACT

Research on skeletal maturation is essential in orthodontics management.The cervical vertebral maturation method has proved to be effective in assessing the adolescent growth spurt in individual patients. Dental calcification stages are proposed as a more reliable method for determining dental maturity. The high association between cervical vertebral maturation and dental calcification stages, revealed that this method to be first level diagnostic tool to assess skeletal maturity in Malay patients. The aims of this study were to determine chronological age of the cervical vertebral maturation stages and left mandibular canine, first and second premolars, and second molar calcification stages among Malay females and males. It is also to investigate the relationship between the stages of cervical vertebral maturation and left mandibular canine, first and second premolars, and second molar calcification stages among Malay females and males. This is a cross sectional study consisted of 215 Malay subjects, 92 subjects were males (age ranged 10-17 years), and 123 subjects were females (age ranged 8-15 years). The stages of cervical vertebral maturation were assessed from lateral cephalogram according to Baccetti *et al.,* (2002) method. The dental calcification stages were assessed from orthopantomogram radiographs according to Demirjian *et al.,* (1973) method. Spearman rank order correlation coefficient was used to assess the relationship between cervical vertebral maturation and dental calcification. For a better understanding of the relationship between cervical vertebral maturation and dental calcification, percent distributions of dental calcification stages at cervical vertebral maturation stages were calculated. The mean and standard deviations of the

chronological age in years for cervical vertebral maturation stages from CVMS1 to CVMSV were, for males 10.92 (SD0.55), 13.11 (SD1.41), 15.32 (SD1.08), 16.38 (SD0.51), and 16.52 (SD0.42) respectively, and for females 9.77 (SD1.27), 11.14 (SD1.67), 13.17 (SD1.01), 14.30 (SD0.65), and 14.53 (SD0.23) respectively. The mean and standard deviations of calcification stage H for canine, first and second premolars, and second molar were in males 15.05 (SD1.69), 15.18 (SD 1.58), 15.25 (SD 1.59), and 15.95 (SD 1.01) respectively, in females were 13.31 (SD 1.32), 13.45 (SD 1.25), 13.54 (SD 1.22), and 14.06 (SD 0.77) respectively. The correlation coefficients between cervical vertebral maturation and calcification stages of the teeth, ranging from 0.682 to 0.772 for male and 0.543 to 0.727 for female, were statistically significant ($P< 0.01$). For the male and female subjects, the sequence of the correlation from lowest to highest was canine, first premolar, second premolar, and second molar. Most of patient's males (81.5%) and females (88.2%) have not completed second molar stage H at the CVMS II. There is a statistically significant relationship between cervical vertebral maturation and dental calcification stages among Malay. This suggests that tooth calcification stages might be used as the first clinical tool to determine skeletal maturity in Malay patients. However, further studies are recommended in a larger sample size.

CHAPTER ONE

INTRODUCTION

1.1Background of the study

An understanding of growth events is important in the practice of clinical orthodontics. Maturational status can have considerable influence on diagnosis, treatment goals, treatment planning, and the eventual outcome of orthodontic treatment. Prediction of both the times and the amounts of active growth, in the craniofacial complex, would be useful to the orthodontist. This is especially true when treatment considerations are based strongly on the facial growth such as the use of extraoral traction, functional appliances, selection of orthodontic retention and orthognathic surgery (Moore *et al.*, 1990).

Many researchers indicated that chronological age is not a reliable indicator to evaluate maturity status of a child (Hunter, 1966, Fishman, 1979, Houston, 1980). As such, the maturity status of a child is best estimated relative to specific stages of physiologic maturity (Demirjian *et al.*, 1985). Physiologic age is estimated by the maturation of one or more tissue systems, and it is best expressed in terms of each system studied. Physiologic age can be estimated by somatic, sexual, skeletal, and dental maturity (Moorrees *et al.*, 1963).

Skeletal maturity refers to the degree of development of ossification in bone. During growth every bone goes through a series of changes that can be seen radiologicaly. The sequence of changes is relatively consistent for a given bone in every person. The timing of the changes varies because each person has his or her own biologic

clock. There are some exceptions, but the events are reproducible enough to provide a basis for comparison between different persons (Hassel and Farman, 1995).

The hand-wrist radiograph is commonly used for skeletal developmental assessment. The validity of the hand-wrist skeletal maturity in the evaluation of craniofacial growth has been confirmed by numerous studies (Bergersen, 1972, Chapman, 1972, Pileski *et al.*, 1973). However, this method requires an additional radiograph for hand-wrist in addition to the routine radiographic records required for orthodontic patients such as lateral cephalogram and orthopantomogram.

Recently, a series of investigations performed in different parts of the world have confirmed the validity of the cervical vertebral maturation (CVM) method, mostly by comparing it with the hand and wrist method (Hassel and Farman, 1995, San Roman *et al.*, 2002, Gandini *et al.*, 2006).

The CVM has proved to be effective to assess the adolescent growth peak in both body height and mandibular. The ossification events in the cervical vertebrae begin during fetal life and continue until adulthood. Therefore, maturational changes can be observed in the vertebrae during this interval, which covers the period when orthodontic treatment is typically performed in the growing patient. The CVM method eliminates radiation exposure for orthodontic patients and utilizes the lateral cephalogram, a film routinely used for diagnosis and treatment planning in orthodontic clinics (Baccetti *et al.*, 2002).

Baccetti *et al.* (2002) presented the new CVM method with five maturational stages Cervical Vertebral Maturation Stage (CVMS) I through (CVMS) V, instead of Cvs 1 through Cvs 6 in the former CVM method. The peak in mandibular growth occurs between CVMS II and CVMS III, and it has not been reached without the attainment of both CVMS I and CVMS II. CVMS V is recorded at least two years after the peak.

However, cervical vertebrae maturation method required longitudinal follow-up for accuracy. Knowing the stage does not allow a clinician to determine the timing of maturation with sufficient accuracy. This is particularly important for females because they have shorter pubertal spurts and complete their growth earlier than males (Ozer et al., 2006). When CVMS I are diagnosed in the individual patient with mandibular deficiency, the clinician can wait at least one additional year for a radiographic reevaluation aimed to start treatment with a functional appliance. As CVMS II represents the ideal stage to begin functional jaw orthopedics (Baccetti *et al.*, 2002). That means orthodontic patient need more than one lateral cephalogram radiograph to assess skeletal maturity. Therefore, any method that could identify skeletal maturity is helpful to eliminate radiations dose for orthodontic patients, especially if the method can be determined without additional radiograph.

Dental maturity can be estimated by the stage of tooth emergence or tooth calcification. The tooth calcification is proposed as a more reliable criterion for determining dental maturation (Demirjian, 1978).

If a strong association exists between CVM method and dental calcification stages, the stages of dental calcification could be used as a first level diagnostic tool to estimate the timing of the adolescent growth spurt in Malays. As dental calcification stages can be assessed from periapical and orthopantomogram radiographs, in dental clinics taking a periapical and orthopantomogram radiographs is more definitive to determine caries and pathology instead of a lateral cephalogram. That is a practical reason for attempting to assess skeletal maturity from tooth calcification (Uysal *et al.*, 2004).

Many researchers have reported significant correlations between skeletal and dental maturity (Krailassiri *et al.*, 2002, Basaran *et al.*, 2007). Others have reported insignificant correlations between skeletal and dental maturity (Green 1961, So, 1997). Racial variations in the relationship between the calcification stages of individual teeth and skeletal maturity have been reported previously (Chertkow, 1980, Mappes *et al.*, 1992).

To date, little is known about this relationship among Malay subjects. The aim of this study was to investigate the relationship between the stages of cervical vertebral maturation and dental calcification among Malays. The findings from this study may establish a valid clinical tool to determine skeletal maturity in Malays by using the stages of dental calcification.

1.2 Objectives

1.2.1 General

To determine the stages of skeletal maturation among Malay subjects by using cervical vertebral maturation and dental calcification.

1.2.2 Specific

1. To determine chronological age of the cervical vertebral maturation stages among Malay female and male.
2. To determine chronological age of left mandibular canine, first and second premolars, and second molar calcification stages among Malay female and male.
3. To investigate the relationship between cervical vertebral maturation stages and left mandibular canine, first and second premolars, and second molar calcification stages among Malay female and male.

1.2.3 Hypotheses

There is a relationship between the stages of cervical vertebral maturation and left mandibular canine, first and second premolars, and second molar calcification stages.

CHAPTER TWO

LITERATURE REVIEW

2.1 Facial growth indicators

The human body undergoes dimensional changes throughout life. Stature, for instance, is characterized by an intensive growth during adolescence until about 20 years of age (Forsberg, 1979). Facial growth is closely related to growth of the body as a whole, therefore accelerates considerably during adolescence (Ochoa and Nanda, 2004). Cephalometric studies indicated that the facial growth rate is not constant throughout the development period. The intensity, onset, and duration of the pubertal peak of facial growth have great variations among patients (Silveira *et al.*, 1992).

Therefore, various indicators to evaluate facial growth in orthodontic patients were used; these include somatic, sexual, skeletal, and dental maturity. Strong relationships among indicators imply a concordance of controlling mechanisms, which serve orthodontists in diagnosis and treatment planning. Valid associations also provide a means of prediction, allowing judgments to be based on a single examination. This is particularly important during adolescence when changes in growth rate can influence treatment results (Demirjian *et al.*, 1985).

2.2 Somatic maturity

Somatic maturity is recognized by the annual growth increments in height or weight (Krailassiri *et al.*, 2002). The pattern of somatic maturity during the first two decades of human life is often categorized into four intervals infancy, childhood, adolescence, and adulthood Figure 2.1.

First interval is infancy. It is the first year of life but not including the first birthday. Second interval is childhood, which extends from the end of infancy to the start of adolescence. During infancy and childhood, the velocity of somatic maturity is decelerating (Malina *et al.*, 2004).

Third interval is adolescence from about 8 to 19 years in girls and 10 to 22 years in boys. During adolescence the velocity of somatic maturity accelerates, reaches a peak velocity and then decelerates until adulthood is achieved. Fourth interval is adulthood the velocity of somatic maturity decelerating during this interval (Malina *et al.*, 2004).

Bergersen (1972) reported that there is no difference in the onset of the adolescent growth spurt in body height, facial height (Nasion-Menton), or mandibular length (Articulare-Gnathion). Other studies have also shown an association between peak velocity of facial growth and peak velocity of stature during adolescence (Bishara *et al.*, 1981, Lewis *et al.*, 1985).

Unfortunately, peak velocity of stature recognized by several measurements repeated at regular intervals (example, every 3 months) to construct an individual curve of growth velocity, which is not practical in orthodontic clinics (Franchi *et al.*, 2000).

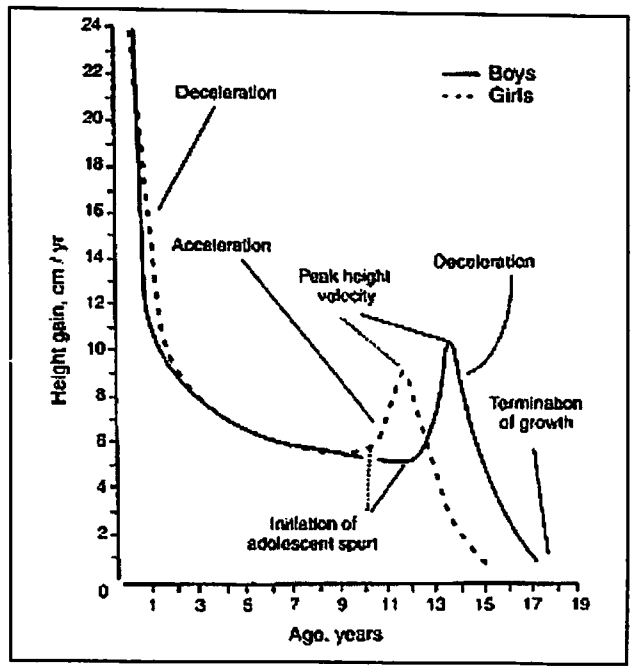

Figure 2.1 Velocity curve for height (Malina *et al.*, 2004)

2.3 Sexual maturity

The changes of secondary sex characteristics, breast development and menarche in girls, penis and testes (genital) development and voice changes in boys and pubic hair in both sexes are characterized as sexual maturity (Malina *et al.*, 2004).

There are close association between sexual, somatic, and skeletal maturity (Hagg and Taranger, 1982, Demirjian *et al.*, 1985). However, some girls, particularly those who are maturing much earlier or later than their peers, may deliberately give false answers when they are asked whether or not menarche has occurred. In orthodontic clinics, it is not possible to use breast development in girls, and penis and testes (genital) development in boys, because that would require a physical examination. Voice change in boys can be applied only after a serial recording, which is not practical in orthodontic clinics (Hagg and Taranger, 1982).

2.4 Skeletal maturity

The assessment of skeletal maturity is an important method in the evaluation, follow up, and timing of therapy in children with growth disorders, such as constitutional growth retardation and growth hormone deficiency, as well as endocrinological diseases, such as hypothyroidism, congenital adrenal hyperplasia, and precocious puberty (Uysal *et al.*, 2004).

In orthodontic clinics, a common reason to assess skeletal maturity for patients is to evaluate craniofacial growth (Uysal *et al.*, 2004). The hand–wrist and the cervical vertebrae are commonly used to assess skeletal maturity in orthodontic clinics.

2.4.1 Hand-Wrist bone

The ossification events of the hand–wrist have been the most frequently used as skeletal maturity indicator. This is due to many ossification centers available in this area that undergo changes at different times and rates (Flores-Mir *et al.*, 2004).

Two general approaches have been described to assess hand-wrist radiograph (Flores-Mir *et al.*, 2004). The first approach consists of two methods;

1. Greulich and Pyle introduced an atlas as a standard of comparison. The atlas is composed of plates of ''typical'' hand wrist radiographs at six-month intervals of chronological age. Each bone of the subject's hand-wrist is compared with the corresponding bones in the atlas, and is assigned an age in months. All ages are averaged yielding the ''mean skeletal age'' of the individual. In clinical use, this approach is often shortened to a gross assessment to find the best match of the individual with one of the plates.

2. Tanner *et al.* (1983) method compares an individual with radiographic standards of skeletal maturity of "normal" children of similar age and sex. Individual bones are rated using a biological weighted scoring system to assign a skeletal age.

The second general approach uses specific indicators to relate skeletal maturation to the pubertal growth curve. A number of indicators have been described in the literature including onset of calcification of the sesamoid, state of calcification of the hook of the hamate, and staging of the middle phalanges of the third finger (Hunter, 1966, Bjork and Helm, 1967, Chapman, 1972, Bergersen, 1972, Pileski *et al.*, 1973, Houston, 1980, Fishman, 1982).

In this chapter, the system presented by Bjork, and Grave and Brown according to Uysal *et al.* (2004), and Fishman (1982) will be described. The two systems commonly used to assess skeletal maturity in previous studies of relationships between skeletal and dental maturity.

Uysal *et al.* (2004) evaluated skeletal maturation from hand-wrist radiographs, by using nine ossification events according to the systems of Bjork, and Grave and Brown:

Stage 1 (PP2): The epiphysis of the proximal phalanx of the index finger (PP2) has the same width as the diaphysis.

Stage 2 (MP3): Epiphysis of the middle phalanx of the middle finger (MP3) is of the same width as the diaphysis.