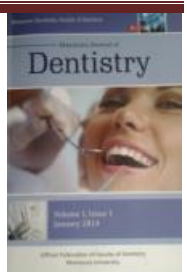
The relationship between dental calcification stages and skeletal maturation



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Abstract:

The aim of the study was to investigate the relation between dental calcification stages and the skeletal maturation in hand and wrist region and cervical vertebrae.The sample include panoramic,handwrist, and lateral cephalometric radiographs of 550 subjects aged from 6.5to 17 years. Dental development was rated and skeletal maturation was evaluated.Thecorrelation was a highly significant positive correlationbetween dental calcification stages and hand wrist maturation stages ranged from 0.82 to 0.86 for females and 0.86 to 0.88 for males. The correlation between dental calcification and cervical vertebral maturation was ranged from 0.82 to 0.84 in females and 0.80 to 0.83 in males.Dental calcification stages can be used as a diagnostic tool for determining the growth in orthodontic patients.

Keywords

Skeletal maturation, dental calcification,cervical vertebral maturation stages,hand wrist maturation.

Introduction

The great role of optimal treatment timing in the effectiveness of various treatment protocols for correction of the majority of orthodontic and dentofacial orthopedic malocclusions is linked tightly with identification of periods of craniofacial growth that determine the growth potential of the patient which is not even from childhood to adolescence. [1]

Determination of the periods of accelerated growth which called pubertal growth spurt (PGS) as individual patient's optimal maturational stage is characterized by wide personal variations in onset, duration, and rate of occurrence.[2, 3]

Although growth incidents occur in a reasonably constant sequence, the ages at which they are reached vary considerably among children. Therefore, chronological age is not a reliable indicator in the prediction of human growth and development because of individual variations in factors such as gender, race, environment, and nutrition.[3, 4]

The developmental status of a child is generally assessed in relation to physical events that take place during the progression of growth. Biological age or physiological age is the predictor which measure growth progression toward maturity. This biological age can be measured from assessment of one or more somatic maturity indicators such as body weight, body height, sexual maturation characteristics, skeletal maturation, and dental development.[5]

Skeletal maturation assessment is done by visual inspection of the developing bones from their initial appearance and their subsequent ossification-related changes in shape and size. During the growing process, each bone undergoes a series of changes which are clear visible by radiography. The hand wrist radiograph has been considered to be the most standardizedcommonly usedindicator for skeletal maturation assessment because of the availability of different types of ossification bony centers in this anatomic region that undergo changes at different times and rates.[6, 7]

The method based on cervical vertebral maturational changes at different developmental stages that correlate with facial and somatic growth in growing subjects has gained increasing interest as a reliable biologic indicator of individual skeletal maturity by observing the morphologic alternation in the shape and size of the body of cervical vertebrae. The assessment is performed on the lateral cephalogram which is routinely required for orthodontic diagnosis and treatment planning.[2, 8]

The use of specialized radiographs for growth assessment has been questioned in concern of radiation hygiene and safety problems in which the patient bears additional radiographs. Keeping in mind the ALARA (As Low as Reasonably Achievable) principle for radiographic use, dental maturation which could be determined easily without additional exposure to radiation through the routinely requested diagnostic radiographshas been reported as a predictor of skeletal maturation.[9-12]

Materials and methods

Study design

The design of the study was a retrospective cross-sectional descriptive study of radiographs. These were panoramic, hand-wrist, and lateral cephalometric radiographs. The sample was collected from pretreatment records of patients in x-ray centers and also from database of orthodontic departments in Mansoura University, Tanta University, and Cairo University, Egypt in the period from 2014 till 2018.

Sample

Sample size calculation: using DSS.research.com Sample Size Calculator, assuming that high mineralization percentage in female at canine was 97.37% and male 100.0% at α error 5% (confidence 95%) and β error 15% which was reported by Lopes et al.[9] (power of the study = 80%), the estimated sample size was 341 subjects.

After exclusion of 37 subjectsthe sample was 513 pretreatment subjects (220 boys, and 293 girls) aged between 6.5 and 17.3 years of age. The selected subjectswere divided between ages by sampling technique methods to be representative for each age.

All radiographs were assessed with visual inspection after coding of each one with a numerical ID without knowledge of either age, gender or even the other same file radiographs of the subject so as, blinding was done to prevent observer bias. All digital radiographs were viewed on the same computer using windows photo viewer on a notebook with a light emitting diode in high definition screen. The observer was allowed to use the "Zoom" tool for magnification of selected regions of interest and to change brightness and contrast of the image in order to obtain more accurate assessment of the developmental stage.

Dental maturity assessment

In this study the examined teeth included were; the mandibular left canine, first premolar, second premolar, and second molar. In case of any missing or overlapped radiographic image of mandibular left teeth, the mandibular right teeth that were corresponded to the missing teeth, were examined, as tooth mineralization of homologous teeth was found to be symmetrical.Dental calcification of the selected teeth was rated according to method described by Demirjian et al.[13] in which all selected teeth were rated on a scale of 1 to 8 stages of mineralization (A-H) for each tooth. The rating was determined by following carefully the criteria of each stage, and by comparing the subject tooth in the panoramic radiograph with the diagrams and illustrative radiographic pictures (figure 1).

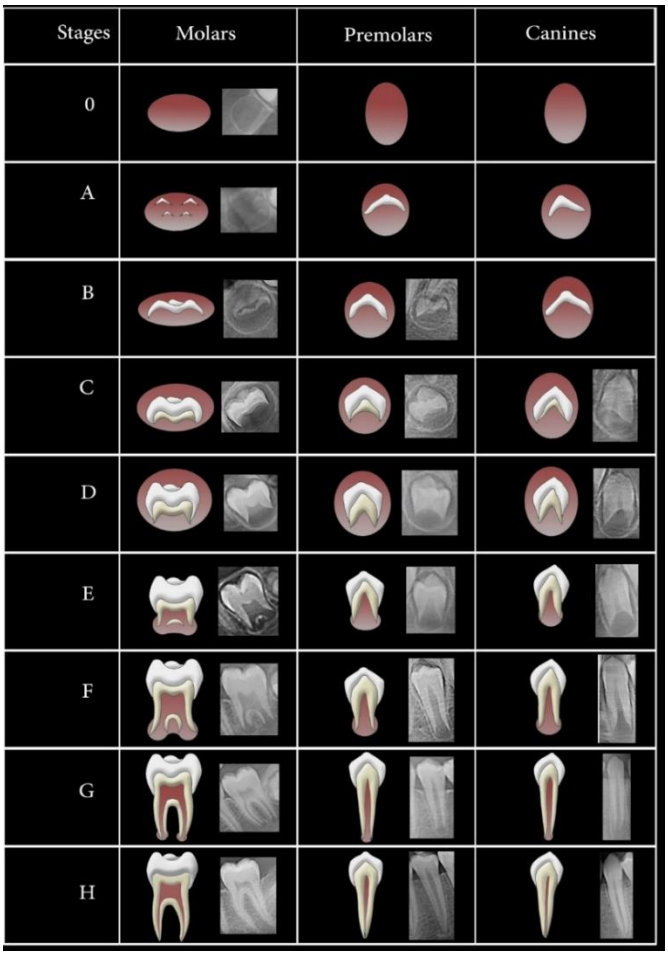

Figure 1: Dental calcification stages of Demirjian system.

Skeletal maturity assessment

1. Hand wrist radiographic evaluation

Hand-wrist radiographs were assessed as a skeletal maturation indicator according to the method described by Grave and Brown[5]. This method includes 14 stages of bone ossification events, which could be grouped into two divisionsossification of individual bones and epiphyseal changes. Events in individual bones were initial ossification of pisiform (Pisi), initial and advanced ossification of hook of hamate (H-1, H-2), and initial ossification of ulna metacarpophalangeal sesamoid of the first finger (S) (figure 2).

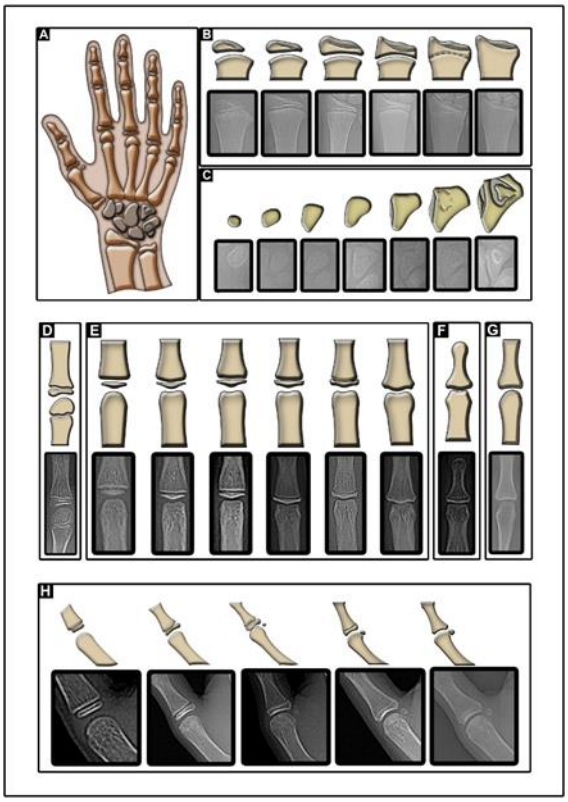

Figure 2:hand wrist maturation stages according to Grave and Brown method.

A. Hand wrist anatomy.	**E. Middle phalanx of the middle finger maturation.**
B. Distal end of radius bone maturational stages.	**F. Epiphyseal union of distal phalanx of third finger.**
C. Hamate bone development.	**G. Epiphyseal union of proximal phalanx of third finger.**
D. Epiphyseal plate of proximal phalanx of second finger.	**H. Metacarpophalangeal joint of first finger.**

2.Lateral cephalometric radiographic evaluation

1. Cervical vertebrae were assessed as askeletal maturation indicator according to the method described by Baccetti et al.[2]. This method based on visual inspection of the morphologic characters of the second through the fourth cervical vertebrae in a single cephalogram. The morphology of the odontoid process of the second cervical vertebra (CV2), the body of the third cervical vertebra (CV3), and the body of the fourth cervical vertebra (CV4) were evaluated according to two sets of variables which werePresence or absence of a concavity at lower border of the body **and shape of the body of cervical vertebrae.**

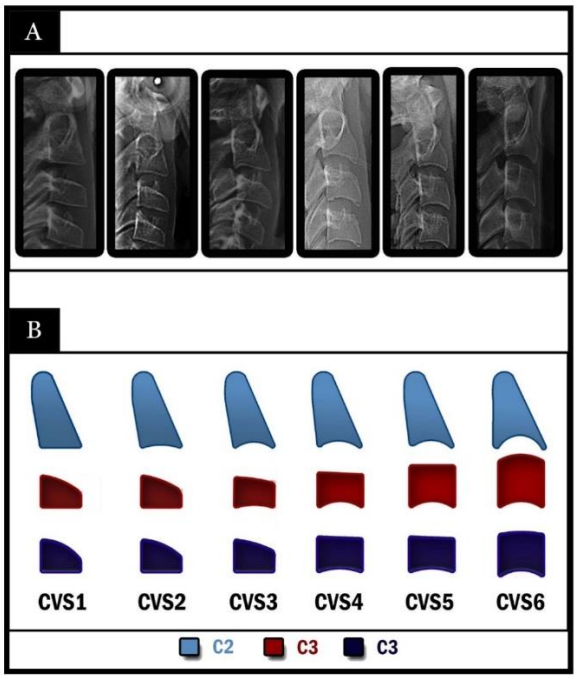

Figure 3: cervical vertebral maturity stages
A- Radiographic appearance of CVM stages.
B- Schematic representation of CVM stages.

Statistical analysis:
Data were entered and analyzed using SPSS software (version 21).Chi-Squaretest was used for comparison of qualitative data for two groups. Independent-Samples t-test was used for comparison of quantitative data between two groups if data were normally distributed in both groups. Pearson' correlation was used to determine the strength and direction of a linear relationship between two continuous variables while Spearman's correlation was used to measure the strength and direction of the association/relationship between two continuous or ordinal variables.
Results
The results showed a statistically high significant positive correlation between each pair of the 6 studied parameters.

The highest correlation was found between HWM and CVMS (r = 0.938) which was slightly higher in females (r = 0.939) than in males (r = 0.922). The correlation between dental calcification and hand wrist maturational stages was generally higher than correlation between dental calcification and cervical vertebral maturational stages. The second molar tooth was the highest tooth calcification stages correlated with skeletal maturational stages in female subjects. The second premolar tooth was the highest tooth correlated with cervical vertebrae maturational stages in male subjects. The first premolar tooth was the tooth with highest correlation with hand wrist maturational stages in male subjects (table 1).

Table 1: Correlation between dental calcification and skeletal maturation stages in hand wrist and cervical vertebrae.

Gender	Female		Male	
Parameter	HWMS	CVMS	HWMS	CVMS
DM Canine	0.824	0.821	0.858	0.803
DM 1st Premolar	0.836	0.823	0.876	0.819
DM 2nd Premolar	0.849	0.822	0.869	0.825
DM 2nd Molar	0.857	0.841	0.862	0.813
HWMS	__	0.939	__	0.922
CVMS	0.939	__	0.922	__

Data are presented as Spearman's correlation coefficient (rs). All correlations were highly significant (p<0.0005). DM: Dental mineralization. CVM: Cervical vertebral maturation. HWM: Hand wrist maturation.

Discussion

The ideal time for correction of the malocclusion with a skeletal discrepancy still a controversy in contemporary orthodontics, the determination of the growth phase and development of the growing patient, could be a leading factor in the choice of treatment approach and the optimal timing to start that treatment.[2, 14, 15]

Many previous studies were with agreement with our results using the same assessment methods whichwere used in this study. Perinetti et al.[11], Chen et al.[16], and Kumar et al.[17] were found statistically significant positive correlation between dental calcification stages and skeletal maturation of cervical vertebrae. Similarly, the previous literature [9, 10, 18, 19] confirmed the significance in the correlation between dental mineralization and hand wrist maturation signals but with a varying degree.This conflict between the results of previous studies may be attributed to the different methods used for the assessment of skeletal and dental maturity, different statistical methodologies, racial differences, unequal numbered, or unequal aged examined samples.[20, 21]

Conclusion

A strong association exists between the dental calcification stages and skeletal maturation in the Egyptian population.

Therefore, the use of dental calcification stages as a valuable measure in estimating skeletal maturation and to determine

the growth status of orthodontic patients can be used with ease.

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