Utility of panoramic radiography for identification of the pubertal growth period

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Introduction: Our aim in this study was to investigate the association between dental mineralization stages and the periods of the pubertal growth spurt (PGS). **Methods:** The sample included panoramic and hand-wrist radiographs from 491 subjects (222 boys, 269 girls) aged 7 to 17 years. Dental development was rated, and skeletal maturation was evaluated. The relevant associations were investigated by analysis of ordinal multinomial logistic regression. **Results:** The second molar (odds ratio [OR] = 4.34) and the first premolar (OR = 2.45) were the best growth predictors for girls. For boys, the second molar (OR = 6.80), second premolar (OR = 2.41), and canine (OR = 3.21) proved to be the best predictors. Stages D and E of the second molar for girls, and stages E and F for boys, corresponded to the onset of the accelerated growth spurt. Stage F of the second molar for girls and stage G for boys corresponded to the peak of the PGS. At the end of the PGS, most teeth had already attained apical closure. In girls, however, most second molars were found at stage G. **Conclusions:** An association exists between the dental mineralization stages and the periods of the PGS, especially for second molars. Panoramic radiographs can be used as the first diagnostic tool to estimate the pubertal growth period. (Am J Orthod Dentofacial Orthop 2016;149:509-15)

It is well known that treatment timing plays an important role in the results of nearly all dentofacial orthopedic treatments for dentoskeletal disharmonies in growing patients.[1] The skeletal maturation status of a child aids in evaluating how much growth still remains and whether the pubertal growth spurt (PGS) has been reached or completed. Because of variations in the timing of the PGS, chronologic age is not a valid indicator of skeletal maturation.[2,3] However, the concepts of biologic or physiologic age have been proposed previously. Biologic age is based on the degree of maturation of different tissue systems that can be estimated by somatic, sexual, skeletal, and dental maturation.[2,4]

The assessment of skeletal maturation consists of the visual inspection of developing bones: various ossification centers of the skeleton, such as the hand and wrist, foot, ankle, hip, elbow, and cervical vertebrae, can be used.[5] Skeletal development has most commonly been determined using hand-wrist radiographs[6-8] and lateral cephalograms.[1,9] However, the use of such radiographs has been questioned because of radiation hygiene and safety problems, in that it requires patients to have additional radiographs.[2]

Dental maturation detected with radiographic methods has been reported to be a potential predictor of skeletal maturation.[3,5,10-13] The ability to recognize dental development stages through the examination of periapical or panoramic radiographs by most orthodontic or pediatric dental practices is a key reason that studies should attempt to assess physiologic maturation without resorting to hand-wrist radiographs.[3] Moreover, no additional exposure to radiation would be necessary if the periods of the PGS were identified through panoramic radiographs (a commonly requested diagnostic radiograph), bearing in mind the "as low as reasonably achievable" principle.

Growth and development of children and adolescents are influenced by ethnic origin, climate, nutrition, socioeconomic level, and urbanization.[14] In spite of all these

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, April 2015; revised and accepted, June 2015.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2015.06.030

causative factors of variations in the timing of the PGS, high correlations have been reported between dental and skeletal maturation.[2,3,5,10-13,15] However, a high correlation is a natural tendency because both are in progress. A high correlation coefficient does not provide information about whether the dental maturation stage is satisfactory for diagnostic identification of the skeletal maturation stage.[16,17] Moreover, a high correlation coefficient does not identify which teeth and their mineralization stages are associated with skeletal maturation. Therefore, it is important to identify the teeth and the corresponding mineralization stages related to the different stages of maturation.

The aim of this study was to identify the pubertal growth period with the dental mineralization stages using panoramic radiographs, which should lead to a reduction in the number of radiographs needed during treatment and benefit the patients economically. The best predictor teeth were identified.

MATERIAL AND METHODS

This cross-sectional study included both panoramic and hand-wrist radiographs of 491 subjects (222 boys, 269 girls) selected from the database of an oral radiology clinic in Piracicaba, Brazil. All radiographs were obtained with the same equipment.

The selection criteria included (1) chronologic age from 7 to 17 years; (2) white ethnicity and well nourished and free of serious illness; (3) no abnormal dental conditions, such as impaction, transposition, and congenitally missing teeth; (4) no history of trauma or disease to the face and the hand-wrist regions; (5) no previous orthodontic treatment; (6) no permanent teeth extracted; and (7) both images (panoramic and hand-wrist radiographs) taken at the same time.

Subjects who had not started the maturation process were excluded.

All radiographs were assessed using Windows Photo Viewer (Microsoft, Redmond, Wash) on a notebook with a light-emitting diode 14.0-in high-definition screen (1366 × 768 pixels) (Dell, Round Rock, Tex), by 2 calibrated oral radiologists (L.J.L, T.O.G.) under dim light conditions. The observers were allowed to use the "zoom" tool and to change the brightness and contrast of the images. When a consensus could not be reached between the 2 examiners, a third radiologist (D.Q.F.) assisted in making the decision. The assessment of each imaging modality (panoramic and hand-wrist radiographs) was performed separately.

Tooth mineralization was rated according to the method described by Demirjian et al[18] in which 1 of the 8 stages of mineralization (A-H) was assigned for each tooth (Fig). In this study, the examined teeth included the mandibular left canine, first and second premolars, and second molar. In case of any missing mandibular left teeth, the mandibular right teeth that corresponded to the missing teeth were examined.

Skeletal maturation was assessed according to the method described by Grave and Brown.[6] This method includes 14 stages of bone ossification, which represent 3 growth periods: the onset, the peak, and the end of PGS (Table I).

Statistical analysis

The statistical analyses were performed using software (version 9.2; SAS, Cary, NC). The significance level was set at 5%. The analyses were the following.

1. The means of the chronologic ages for both sexes in the 3 periods of skeletal maturation were compared by 2-way analysis of variance (ANOVA) and the post hoc Tukey test.
2. The analysis of ordinal multinomial logistic regression evaluated which teeth had mineralization associated with skeletal maturation. This analysis is used when studying a categorical dependent variable with more than 2 ordinal responses.[19] The use of the logistic model for ordinal responses has a simple interpretation and greater power. The quality of the models' adjustments was analyzed by the log of likelihood ratios and the Akaike information criterion (AIC). It estimates the quality of each model; the adjusted model with the lowest value of log-likelihood ratios and AIC are selected. Lower values indicate higher quality and therefore better models.
3. The percentages of the distribution of the stages of mineralization for each tooth were calculated to study the relationships between the stages of mineralization of the teeth and skeletal maturation.

RESULTS

Table II shows the distributions of the mean chronologic ages and sexes of the sample. ANOVA showed differences between the sexes ($P < 0.05$) and between the skeletal maturation periods ($P < 0.05$). A consistently earlier occurrence for each skeletal maturation stage was observed more often in the girls than in the boys. The mean chronologic age of the girls was approximately 1.8 years (range, 1.7-2.0 years) younger than that of the boys.

The ordinal multinomial logistic regression analyses between the skeletal maturation stages and the mineralization stages of the teeth are presented in Table III for girls and Table IV for boys. The analysis of ordinal