Tooth mineralization stages as a diagnostic tool for assessment of skeletal maturity

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Introduction: The objective of this study was to determine whether dental calcification can be used as a first-level diagnostic tool for assessment of skeletal maturity. **Methods:** A total of 150 healthy subjects (79 boys, 71 girls; mean age, 12.19 ± 2.03 years; range, 8-16 years) were enrolled in the study. Dental maturity was assessed through the calcification stages from panoramic radiographs of the mandibular canine, the first and second premolars, and the second molar. Determination of skeletal maturity was according to the modified middle phalanx of third finger (MP3) stages method on digital radiographs. **Results:** Diagnostic ability was evaluated according to the dental maturation stages for each tooth for identification of the MP3 stages and the growth phases (prepubertal, pubertal, postpubertal) using positive likelihood ratios. Dental maturation stage E of the first premolars and the combination of canine stage F, first premolar stage E, second premolar stage E, and second molar stage D (FEED) gave the highest values for identification of the prepubertal growth phase, and stage H of the second molar had the highest value for identification of the postpubertal growth phase. **Conclusions:** Dental maturation assessment is only useful for diagnosis of the prepubertal and postpubertal growth phases. (Am J Orthod Dentofacial Orthop 2014;145:7-14)

Treatment timing has a significant role in the outcome of all dentofacial orthopedic treatments for dentoskeletal disharmonies in growing patients.[1] Prior knowledge of the amount of growth remaining would be extremely useful for forecasting treatment outcome, taking advantage of growth when necessary and trying to minimize growth when undesirable.[2] For growth modification to be successful, it is absolutely essential that it start at the right time. Optimal timing for treatment is different in various malocclusions. According to Bacetti et al,[1] treatment protocols aimed to enhance or restrain maxillary growth take advantage of treatment performed before the adolescent growth spurt, whereas treatment regimens aimed to enhance or restrain mandibular growth produce greater effects when the pubertal growth spurt is included in the treatment interval.

The relationship between dental and skeletal maturity has been investigated. Tooth emergence as a marker of skeletal maturity has been shown to be poorly correlated with skeletal maturity.[3-5] However, dental calcification stages detected through radiographic methods appear to be highly correlated to skeletal maturity.[2,6-9]

Dental maturity assessment has the advantage of being a simple procedure that can be carried out on panoramic radiographs that are routinely used for various purposes and on intraoral radiographs that can be taken with minimal irradiation to the patient.

A high correlation coefficient does not provide information about whether the dental maturation stage is satisfactory for diagnostic identification of the skeletal maturation stage on an individual basis. Perinetti et al[10] analyzed the diagnostic ability of the dental maturation phases for the skeletal maturation phases using the cervical vertebral maturation stages and concluded that although dental and skeletal maturity are highly correlated, their diagnostic ability is limited.

In a pediatric patient, the use of a thyroid collar is mandatory while taking cephalometric radiographs. However, Wiechmann et al[11] and Sansare et al[12] concluded that the thyroid collar masks landmarks mainly used for analysis of skeletal maturity. Madhu et al[13] studied the correlation between the developmental stages of the middle phalanx of the third finger (MP3) as seen on an intraoral periapical radiograph and cervical vertebral stages, and they concluded that the MP3 can be used as the sole indicator for skeletal maturity.

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Rajagopal and Kansal[14] and Ozer et al[15] correlated the cervical vertebral maturation stages with modified MP3 stages and concluded that the MP3 stages can be used to assess a subject's skeletal maturation. Rajagopal and Kansal showed that recording the modified MP3 stages using periapical x-ray films can be an accurate, simple, practical, and economical growth indicator for making decisions on treatment planning.

Hence, the aim of this study was to determine whether dental calcification can be used as a first-level diagnostic tool for assessment of skeletal maturity with the MP3 stages.

MATERIAL AND METHODS

This study has a cross sectional design. With a 95% confidence interval (CI) and 80% test power, a sample size of 150 was calculated. We enrolled 79 boys and 71 girls in the age group of 8 to 16 years (mean age, 12.19 ± 2.03 years). Informed consent was obtained from all the subjects, and the study protocol was approved by the ethical committee of Meenakshi Ammal Dental College, Chennai, Tamil Nadu, India. The subjects had no history of congenital, developmental, or hormonal disturbances that could affect their growth. They had no impacted teeth, transposed teeth, or history of trauma or injury to the face and hand and wrist regions.

The subjects were scheduled for enrollment at their first clinical examination, when digital dental panoramic radiographs were taken. Digital radiographs of the MP3 region were taken using the procedure described by Abdel-Kader[16] (Fig 1).

Assessment of dental maturity was carried out through the calcification stages according to the method of Demirjian et al[17] from the panoramic radiographs of the left mandibular posterior teeth. Briefly, these stages are defined as follows.

Stage D is when (1) crown formation is complete down to the cementoenamel junction; (2) the superior border of the pulp chamber in uniradicular teeth has a definite curved form and is concave toward the cervical region, and the projection of the pulp horns, if present, gives an outline shaped like the top of an umbrella; and (3) the beginning of root formation is seen in the form of a spicule.

Stage E is when (1) the walls of the pulp chamber form straight lines, the continuity of which is broken by the pulp horns, which are larger than in the previous stage; and (2) the root length is less than the crown height.

Stage F is when (1) the walls of the pulp chamber form a more or less isosceles triangle, with the apex ending in a funnel shape; and (2) the root length is equal to or greater than the crown height.

Fig 1. Patient positioning for a radiograph of the MP3 region with a digital sensor.

Stage G is when the walls of the root canal are parallel and its apical end is still partially open.

Stage H is when (1) the apical end of the root canal is completely closed, and (2) the periodontal membrane has a uniform width around the root and the apex.

A trained postgraduate dental student (S.M.), who was blinded to the skeletal maturation stages, assessed the dental maturity of the mandibular canine, the first and second premolars, and the second molars.

Assessment of skeletal maturity was carried out with the modified MP3 method described by Rajagopal and Kansal[14] (Fig 2) from the digital radiographs. This method comprises 6 stages, defined as follows.

1. MP3-F stage is the start of the curve of pubertal growth spurt: the epiphysis is as wide as the metaphysis; the ends of the epiphysis are tapered and rounded; the metaphysis shows no undulation; and the radiolucent gap (representing the cartilaginous epiphyseal growth plate) between the epiphysis and the metaphysis is wide.
2. MP3-FG stage is the acceleration of the curve of the pubertal growth spurt: the epiphysis is as wide as the metaphysis; a distinct medial and lateral border of the epiphysis forms a line of demarcation at a right angle to the distal border; the metaphysis begins to show a slight undulation; and the radiolucent gap between the metaphysis and the epiphysis is wide.
3. MP3-G stage is the maximum point of the pubertal growth spurt: the sides of the epiphysis have thickened and cap its metaphysis, forming a sharp distal edge on at least 1 side; marked undulations in the