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(REVIEW ARTICLE)

Indicators of skeletal maturity using biochemical and radiographical markers: A review of literature

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Abstract

Skeletal maturation can occur at different ages in each person; diagnosing and predicting skeletal maturation time is very important in orthodontic treatments. Therefore, many methods have been introduced to help diagnose more accurately and at a lower cost. The primary aim of this review is to provide a summary of several methods which are used to determine the skeletal maturity stage.

Keywords: Skeletal maturity; Biochemical markers; Radiographical markers; Review

1. Introduction

People can reach maturity at different ages according to their situations (1). Bone age has been found to be as important as chronological age in evaluating adolescent development (2). It has been reported that there is a relationship between the calcification stage of each tooth and bone maturity. Racial variations in the relationships have also been suggested (3). Considering that many orthodontic treatments are based on growth modification, it is crucial to determine craniofacial skeletal maturity.

Furthermore, the evaluation of skeletal maturity and growth potential can designate the best time for orthodontic treatments (4). Various procedures are based on increased and decreased craniofacial growth, such as using different functional appliances, Determining treatment with or without extraction, selecting and executing orthodontic retention, and Choosing the best time for orthognathic surgery(5). Numerous indicators have been suggested to recognize skeletal maturity. This paper provides a review of several methods that are available for the prediction of the stage of skeletal growth.

2. Biochemical markers

They are materials or structures that can be measured in the body, and skeletal growth can be estimated using them.

- Growth hormone (GH)**:** is a hormone that stimulates growth, cell reproduction, cell regeneration, and Igf1 (6). The amount of this hormone changes under the influence of various factors. Therefore, it is considerably challenging to measure it accurately (7).
- Insulin-like growth factor1 (IGF1): is a hormone similar in molecular structure to the insulin that plays an important role in childhood growth (8). During the growth spurt of puberty, this hormone tends to peak (9). it is stated that IGF-1 could be a factor involved in endocrine, paracrine, or autocrine stimulation in the postnatal

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mechanism of progenitor adrenal cell proliferation and migration(9). It has been reported that it had a moderate correlation with the Hand-wrist radiographs and cervical vertebral stages (10).

- Testosterone (T) and estradiol (E2): are the major sex hormones; they have effect on male bone tissue (11). Estrogen determines the acceleration of bone elongation at puberty, epiphyseal closure, harmonic skeletal proportions, peak bone mass achievement, and bone mass maintenance (12). These markers are low in accuracy and reproducibility (12).
- Alkaline phosphatase (ALP): it is vital in development within the skeleton (13); its amount increases along with the growth rate; also, it is suggested that ALP activity in GCF reflects the biological activity in the periodontium during orthodontic movement (14). Tarvade et al. reported a significant correlation of salivary ALP with median phalanx index skeletal maturation stages. Moreover, the collection of saliva for analysis is not complex, does not require invasive procedures, and does not require very complex equipment (15,16).

3. Radiological markers

3.1. Hand-Wrist Radiographs

The hand and wrist bones consist of 27 small bones. Calcification appears in the epiphyseal plate throughout postnatal development. Therefore, helpful information about skeletal maturation can be obtained from it (17). Hand and wrist radiographs are considered the standard method for diagnosing skeletal maturity and the amount of growth left and determining whether to use a functional appliance or to wait until growth ceases and performing extraction or surgery (17). This method is reliable and correlates cervical vertebrae and dental development. However, radiation exposure is required (18). However, this method's polymorphism and sexual dimorphism in ossification within the hand-wrist area can limit the prediction of skeletal maturity (19,20).

3.2. Lateral cephalogram

Morphological changes in cervical vertebrae during growth can give us helpful information about skeletal maturation. It is reported that this method has less exposure than a radiographic assessment of hand-wrist bones (21). It is possible to assess bone age according to cervical vertebrae with lateral cephalometric radiography, which is usually used in orthodontic treatments. For this reason, this method is straightforward to perform. Since the protective thyroid collar is not an obstacle to distinguishing the C2, C3, and C4 cervical vertebrae, it is possible to reduce the amount of radiation dose that reaches the patient. (18). Also, this method has been introduced as a reliable method to evaluate bone maturity (22). Different methods have been introduced to evaluate the cervical vertebrae, but due to the different parameters, it is impossible to make a decisive conclusion between the different methods (23).

3.3. The frontal sinus

Frontal sinus growth can be associated with general skeletal maturity (24). A significant correlation between the height and width of the frontal sinus and the maturation stage of the cervical vertebrae (CVM) has been reported. However, no correlation was found between the sinus index and the stage of the CVM(25).

4. Skeletal maturity and Facial Growth

Skeletal maturity, which is evaluated using wrist radiography, has been related to the velocity of overall facial growth in horizontal and vertical dimensions, and can change the ratio of facial proportion such as golden proportion (26). Also, the growth velocity of the maxilla and mandible was correlated with skeletal maturity but less than the overall growth of the face (27).

5. Skeletal maturity and dental Calcifications Stages

A significant correlation has been reported between the calcification of canine teeth and mandibular second molars and skeletal maturity in both genders. However, females reach skeletal maturity earlier than males (28). It has been suggested that the calcification of canine teeth can be used as a supplemental diagnostic method in all stages (29). But more studies are needed on this method.

6. Conclusion

It seems that despite the introduction of different methods, Hand-Wrist Radiographs and Lateral- cephalograms are the most reliable, and other methods, such as calcifications stages of permanent canines and second premolars, can be used as a supplemental methods for diagnosis and prediction. Moreover, research has shown that biochemical markers are not appropriate methods for determining skeletal maturity. There is a correlation between Facial growth velocity in horizontal and vertical dimensions and skeletal maturity. Furthermore, a significant correlation between the height and width of the frontal sinus and the maturation stage of the cervical vertebrae (CVM) has been reported.

Compliance with ethical standards

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Disclosure of conflict of interest

There are no conflict of interest between the authors.

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