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Review Article

CVMI and SMI- A Tool for Age Assessment in Orthodontic Patients

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Abstract

Accurate measurement of skeletal maturity is critical to understand the possible etiology, diagnosis, modal¬ity, timing of treatment, and its eventual outcome of various skeletal abnormalities. In Orthodontics growth prediction is an assessment of the amount of growth to be expected. Some important clin¬ical decisions whether to extract or not to extract, use of orthopedic functional appliances, fixed-functional appliances, and some surgical decisions are based on growth of an individual. In this review we researches want to highlight the most important, clinically relevant and easy to use methods of age estimation.

Keywords: Age Assessment; SMI; CVMI

Abbreviations

SMI: Skeletal Maturity Indicators; CVMI: Cervical Vertebrae Maturation Indicator

Introduction

Measurement of skeletal maturity is important in many fields of medical and dental practice. Forensic age estimation lets courts and other government authorities determine the official age of persons whose actual age is unknown. Proof of being under or over the legally defined age limits is required for legal decisions about procedural privileges or social benefits [1]. The assessment of skeletal age in growing orthodontic patients is an essential step in treatment planning and in defining the appropriate treatment timing. Skeletal age is also considered to be the best age amongst chronological and dental age. Growth prediction is an assessment of the amount of growth to be expected. In orthodontics the term refers to the estimation of amount and direction of growth of the bones of the craniofacial skeletal and overlying soft tissues. Assessing maturational status (whether pubertal growth spurt of that child has reached or completed) can have a considerable influence on diagnosis, treatment planning, and the eventual outcome orthodontic treatment in children [2,3]. Successful prediction requires specifying both the amount and the direction of growth, in relation to the reference point [4]. The hand-wrist is the most commonly used site for evaluating skeletal maturity [5]. Meanwhile, when a lateral cephalometric radiograph is taken for diagnosis in a patient planned for orthodontic treatment, the skeletal maturity/age/amount of growth remaining in percentage can also be determined based on the cervical vertebrae in the radiograph, with no need for a hand-wrist radiograph. Hassel and Farman [6].

Fishman developed a system of hand-wrist skeletal maturation indicators (SMI), using four stages of bone maturation at six anatomic sites [7].

In clinical orthodontics it is significant to understand the stage of growth in a growing patient in order to assess the skeletal maturity of the patient, the hand wrist radiograph and cervical vertebra maturation indicator was evaluated from the lateral cephalogram and the skeletal maturity is determined from the hand wrist X ray.

It is a routine procedure for orthodontists to take both hand wrist radiograph for assessing skeletal maturation and cephalometric radiograph to analyse skeletal morphology and direction of growth patterns

Because of individual variation, physiological and anatomical maturity cannot be accurately assessed by age alone. Other parameters, such as growth velocity, secondary sex changes, dental development, and skeletal ossification, have proven of more value [8].

The early hope of those who championed the idea of accurately determining the skeletal age of patients was to coordinate this information with orthodontic treatment so as to maximize the therapeutic effect. Unfortunately, a low correlation has been found between general skeletal maturity and facial growth as measured by common parameters [9].

Orthodontists do not necessarily need to know the exact skeletal age of a patient, or how much individual facial bones may grow during treatment, or even when that growth is likely to occur. They simply need to know whether the patient will grow at all during a one- or two-year treatment period and what percentage of growth can reasonably be expected during that time.

The standard method of evaluating skeletal maturity has been to use a hand-wrist x-ray to compare the bones of an individual's hand with those in published atlases [10].

Methods of Age Assessment

- Non-cephalometric methods
- Cephalometric methods (skeletal assessment)

In our review we want to include second method as it is more reliable, predictable, and reproducible.

SMI (hand-wrist radiograph)

Fishman developed a system of hand- wrist skeletal maturation indicators (SMIs) using four stages of bone maturation at six anatomic sites on the hand and the wrist [3,11].

Also in 1982, Hagg and Taranger created a method using the hand-wrist radiograph to correlate certain maturity indicators to the pubertal growth spurt. Hand wrist radiograph is "the most standardized and studied method of skeletal age assessment", according to Smith in 1982, Fishman published a system for assessment of skeletal maturation on the basis of 11 discrete "skeletal maturity indicator" covering the entire period of adolescence development [12].

The indicators provide identification of the progressive maturation events and are located on a six anatomic sites located on the thumb, third finger, fifth finger and radius.

According to Fishman methods

Four stages

- Epiphysial widening on selected phalanges
- Ossification of adductor sesamoid of the thumb.
- Capping of selected epiphyses over their diaphysis.
- Fusion of selected epiphyses and diaphysis.

Width of epiphysis as wide as diaphysis

- **Third Finger:** Proximal Phalanx
- **Third Finger:** Middle Phalanx
- **Fifth Finger:** Middle Phalanx ossification.

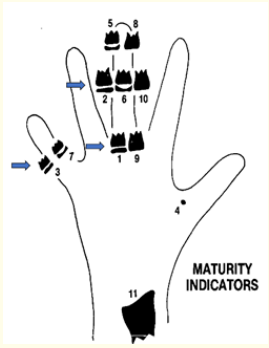

Figure a

Ossification

- Ossification of Adductor Sesamoid of Thumb

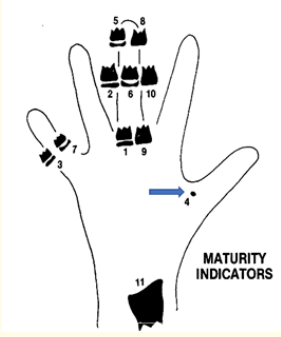

Figure b

Capping of epiphysis

- **Third finger:** Distal Phalanx
- **Third finger:** Middle Phalanx
- **Fifth finger:** Middle Phalanx Fusion of Epiphysis and Diaphysis.

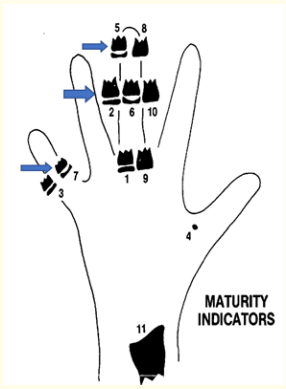

Figure c

Fusion of epiphysis

- **Third finger:** Distal Phalanx
- **Third finger:** Proximal Phalanx
- **Third finger:** Middle Phalanx
- Radius.

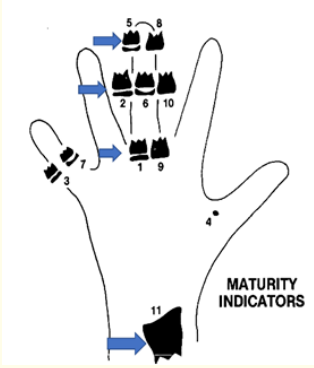

Figure d

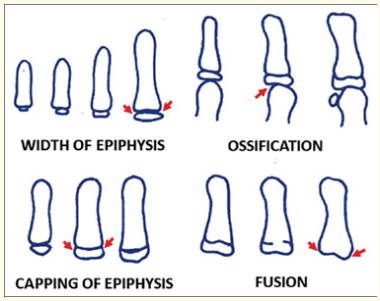

Figure e

Summary of fishman method

CVMI: By Hassel and Farman,in 1995

Cervical vertebrae maturation index or CVMI is stated as follows

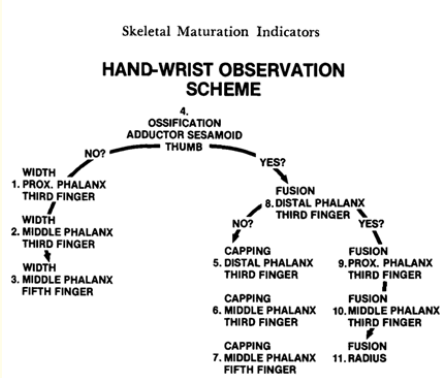

Figure f

Initiation

- Corresponded to a combination of SMI 1 and 2.
- Very significant (80-100%) amount of adolescent growth expected
- C2, C3, and C4 inferior vertebral body border flat tapered from posterior
- Superior vertebral borders are tapered posterior to anterior.

Acceleration

- Corresponded to a combination of SMI 3 and 4
- Significant (65-85%) amount of adolescent growth expected
- Concavities developing in lower borders of C2 and C3
- Lower border of C4 vertebral body is flat
- C3 and C4 are more rectangular in shape.

Transition

- Corresponded to a combination of SMI 5 and 6
- Moderate (25-65%) amount of adolescent growth expected
- Distinct concavities in lower borders of C2 and C3
- C4 developing concavity in lower border of body
- C3 and C4 are rectangular in shape.

Deceleration

- Corresponded to a combination of SMI 7 and 8
- Small (10-20%) amount of adolescent growth expected
- Distinct concavities in lower borders of C2, C3, and C4
- C3 and C4 are nearly square in shape.

Maturation

- Corresponded to a combination of SMI 9 and 10
- Insignificant (5-10%) amount of adolescent growth expected
- Accentuated concavities of inferior vertebral body borders of C2, C3, and C4
- C3 and C4 are square in shape

Completion

- Corresponded to SMI 11
- Adolescent growth is completed
- Deep concavities are present for inferior vertebral body borders of C2, C3, and C4
- C3 and C4 heights are greater in width

Six stages of CVMI

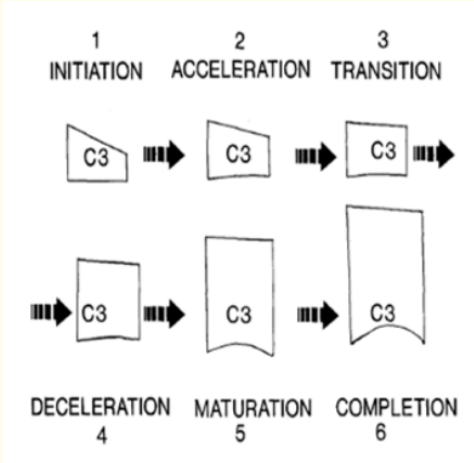

Figure g

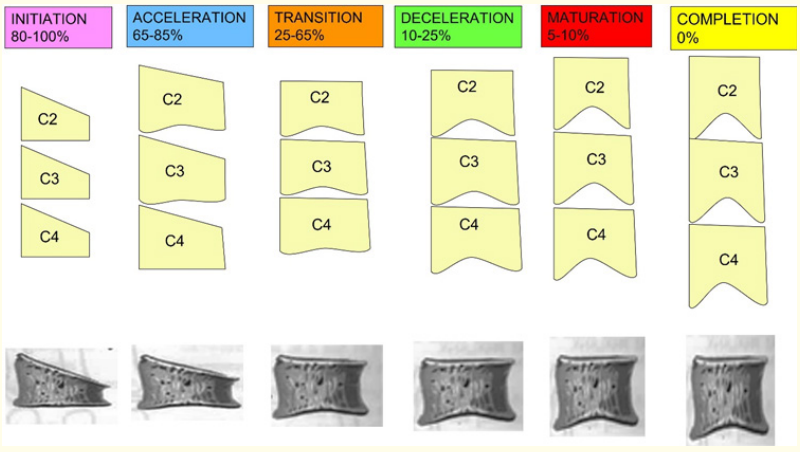

Figure h

Conclusion

Precise evaluation of maturational stage should be an integral part of both diagnosis and treatment. Different authors had reported different methods in an attempt to determine the best indicator of maturity. These include body height, body weight; sexual maturation; Frontal sinus, chronological age, biological age or physiological age; Hand-wrist maturity; Cervical vertebrae; dental eruption; dental calcification stages and biomarkers. Every method has its own advantages, disadvantages, and limitation over the other method. But still researches are being done to explore best method to assess the maturity of an individual.

This review suggests that methods which are simple and non-invasive and do not have risk of additional radiation exposure can be considered as additional diagnostic tool.

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