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CERVICAL VERTEBRAL MATURATION A REVIEW ON CERVICAL VERTEBRAL MATURATION AS A SKELETAL MATURITY INDICATOR

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ABSTRACT

Assessment of skeletal maturity is an important aspect of Dentofacial orthopedics. Timing of the treatment determines the success especially in class II malocclusion with retruded mandible. Even though there are several methods available to assess maturity status, cervical vertebral maturity method (CVM) is a frequently used one. Popularity gained by CVM method may be due its reproducibility, ease of assessment and do not require other additional diagnostic aids.

Introduction

Biological indicators of skeletal maturity refer to somatic changes at puberty emphasizing the interactions between the development of craniofacial structures and modifications in other body regions. But the timing of skeletal maturation varies between individuals as each person has his or her biological clock There are several ways to assess the individual skeletal maturity, which includes) Chronological age

2) Peak height velocity (PHV)[1]
3) Dental age[2]
4) Hand-wrist radiographs[3]
5) Cervical vertebral maturation index (CVMI)

As CVMI does not require additional records (e.g.: hand wrist radiograph) for assessing skeletal maturity it has been routinely used by orthodontic practitioners for decades

Historical perspectives

Don Lamparski in 1972 developed the method of assessing skeletal maturity using cervical vertebrae maturity method as a part of his master's of science thesis at University of Pittsburgh which went unpublished[4]. Later in 1988, O Reilly MT compared mandibular growth changes with maturation of cervical vertebrae and a statistically significant correlation was obtained. In 1995 Hassel B, Farman AG using lateral profiles of second, third and fourth cervical vertebrae developed a reliable ranking of patients according to future adolescent growth potential[6]. Later on CVMI has been used by Baccetti, Franchi and Mc Namara Jr for assessing optimal treatment timing in Dentofacial orthopedics [7].Presently CVMI has become one of the most popular method of assessing skeletal maturity and planning of the treatment accordingly.

Methods of assessing cervical vertebral maturation

I) Hassel and Farman Method[6]

Cervical vertebra maturation indices were determined based on the presence of curvature in the inferior border, shapes of bodies of the dens, C3 and C4 and inter-vertebral spacing. The following six stages were put forward in vertebral development

1. Stage 1(Initiation)

Corresponds to the beginning of adolescent growth spurt with 80% to 100% of growth is expected. During this period the inferior border of C_2, C3and C_4cervical vertebraes are not indented but are flat or slightly convex.

2. Stage 2 (Acceleration)

Growth acceleration begins in this stage with 65% to 85% of adolescent growth expected. Second stage is also named as "Get ready stage" as peak interval will begin about 1 year after this stage is evident.[7] Concavities start to develop at the inferior borders of $C_2$and$C_3$with flat inferior border of C4[5].

It is advised to treat developing Class III malocclusion using functional jaw orthopedics such as Face mask therapy.

3. Stage 3 (Transition stage)

Maximum craniofacial growth velocity is anticipated and 25% to 65% growth can occur in this stage .Distinct notching of lower border C2 and C3 can be observed with at least one of C3 and C4 bodies still remains in the trapezoidal shape.

Functional jaw orthopedic maneuvers yield best results in Class II malocclusion as a part of mandibular skeletal retrusion.

4. Stage 4 (Deceleration)

This stage corresponds to deceleration of adolescent growth spurt with 10% to 25% of adolescent growth expected. Distinct concavities are seen in inferior border of C2, C3 and C4. In this stage, also known as "soap bubble stage ", both the C3 and C4 vertebral bodies are more rectangular horizontal rather than a trapezoidal shape.[7]

The peak in mandibular growth has occurred within 1 or 2 years before this stage

5. Stage 5 (Maturation)

Presence of concavity in lower border of C2, C3 and C4 is no longer a differentiating feature. So the stage 5 also known as "Marsh mellow stage" is differentiated from stage 4 on the basis of shapes of C3 and C4 which has become square[7]. As most of craniofacial growth has got completed with the reach of this stage, the patient can be evaluated for corrective jaw surgery or the placement of endosseous implants.

6. Stage 6(completion)

Concavities on the lower borders of C2, C3 and C4 are still evident. At least one of the bodies of C3 and C4 are rectangular vertical while others are square. Even though patients can be send for corrective jaw surgery during this stage, there is an exception in the case of class III malocclusion. Orthognathic surgery can be planned in class III malocclusion only after assessing the cessation of craniofacial growth using two lateral cephalogram head film taken 6 months apart.

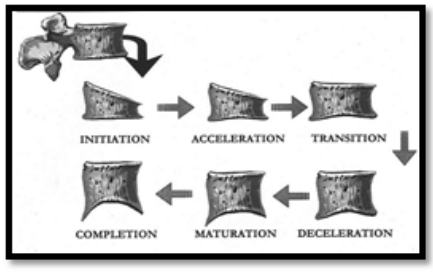

Figure1. Hassel and Farman's stages of cervical vertebral maturation

ii) Improved version of cervical veryebral maturation mathod: Baccetti, Franchi and Mc Namara

Baccetti, Franchi and Mc Namara developed an improved version of cervical vertebral maturity assessment which was done using both the methods of visual and Cephalometric analysis[8,9]. According to this method there are five stages in the cervical vertebrae development.

1. CVMS(cervical maturation stage)I:
Peak growth velocity can occur only 1 year after reaching this stage. Lower border of cervical vertebraes are flat with the exception of slight concavity at the lower border of C2. The shape of bodies of C3 and C4 is trapezoidal.

2. CVMS II:
Concavities are present at the lower border of C2 and C3. The shape of bodies of C3 and C4 can either be trapezoidal or rectangular horizontal. The peak growth velocity can be attained within a year after this stage.

3. CVMS III:
Distinct concavities are present at the lower border of C2, C3 and C4 which shape of bodies of C3 and C4 rectangular horizontal. Peak growth had occurred within a year or two before this stage.

4. CVM S IV:
The lower border of C2, C3 and C4 are still concave in shape. At least one of bodies of C3 and C4 is squared in shape.

5. CVMS V:
Concavities on lower border of C2, C3 and C4 are evident. Either the body of C3 or C4 is rectangular vertical in shape.

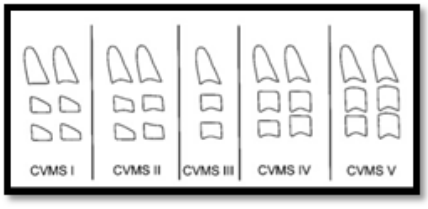

Figure 2: Five stages of cervical vertebral maturation

As the peak mandibular growth occurs within a year reaching CVMS II, it is the ideal stage for functional jaw orthopedic treatments. An average increase of 5.4mm is expected in the year following CVM II.

iii) Evaluation of Cervical Vertebral Maturation Based on Angular measurement

Cervical vertebral maturation assessment is based on modification of Baccetti method. Angular measurement of lower border concavity of C2, C3 and C4 are performed. Angle used are C2 angle, C3angle and C4 angle. Three points, posterior, middle and anterior are considered in the lower border of C2, C3and C4 which is denoted as C2p, C2m, C2a, C3p, C3m, C3a, C4p, C4m and C4a respectively.[10]

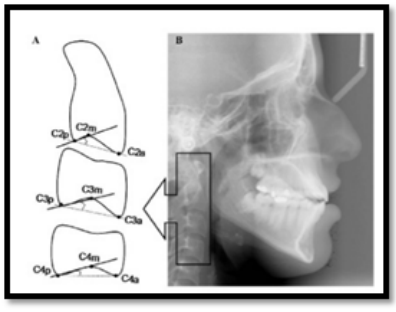

Figure 3
A) Schematic representation of cervical vertebrae.
B) Lateral cephalogram showing cervical vertebrae.

The average value of C2, C3 and C4 angle is calculated and compared with individual CVMS. The obtained minimum and maximum values of C2-C3-C4 angle are used to classify maturation of cervical vertebrae into five stages known as "Cervical Vertebral Maturation Angular Classification".[10]

1. CVMA stage 1: C2-C3-C4 angular measurement is equal to 0˚.
2. CVMA stage 2:C2-C3-C4 angular measurement is greater than 0˚ but less than or equal to 6˚.
3. CVMA stage 3: C2-C3-C4 angular measurement is larger than 6˚ but less than or equal to 10.3˚.
4. CVMA stage 4: C2-C3-C4 angular measurement is larger than 10.3˚ but less than or equal to 17˚.
5. CVMA stage 5: C2-C3-C4 angular measurement is larger than 17˚.

This method can be used for the level of individual skeletal maturity and estimate pubertal growth peak[10]. Further studies are needed to establish norms for CVMA method.

Comparison of CVM method with Hand Wrist bone analysis and other common indexes of maturation

Comparison of hand wrist analysis and cervical vertebral analyses for assessing skeletal maturation shows that there are no significant differences between two analyses[11]. But the use of CVM method limits the risk of additional radiation exposure to hand wrist.

According to study conducted by Mellion ZJ (2013) to compare the relationship of pattern of facial growth to various common indexes of maturation[12]. As an index of maturation, hand wrist skeletal ages appear to offer the best indication of peak growth velocity. Chronological age also provided nearly good results compared to cervical stages.

Error associated with prediction of peak pubertal growth spurt related to height, facial size and mandibular length using statural onset to was lower than the predictions which were based on cervical vertebrae[10].

Comparison of different CVM methods

Several studies are done to compare the efficiency of CVMI and CVMS. Results obtained validated that both CVMI and CVMS are similar. But compared to CVMS which is done by measuring the depth of concavity, vertical height of C2, C3 and C4 by Cephalometric analysis , CVMI method has a distinct advantage of visual analysis[11].

Conclusion

Timing of treatment onset is as critical as the selection of treatment protocol. It is considered as fourth dimension in orthodontics as optimal timing for Dentofacial orthopedics is linked with identification of periods of accelerated growth that can contribute significantly to the correction of skeletal imbalances.

CVM method can be considered as a reliable and efficient biological indicator of growth prediction. It has efficacy for recording peak growth, there is no need for additional radiograph and can be easily recorded. The cervical vertebrae are available in routinely used lateral cephalogram for orthodontic diagnosis and treatment planning. Estimation of shape of cervical vertebrae is straight forward with higher reproducibility of stages.

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