A New Growth Prediction Method Involving Maxillofacial Hard and Soft Tissue Calibrations- a Radiological Analysis.

Abstract:

Objective: Growth prediction is of key importance in pediatric patients as well as growing individuals opting for orthodontic or orthopedic treatment. The objective of this study is to assess a new growth prediction method involving maxillofacial hard and soft tissue calibrations. Orthodontic treatment is most favourable and effective during pubertal growth and hence growth assessment and prediction are significant in planning treatment for dental and maxillofacial abnormalities. It can also be helpful in diagnosis of various growth disorders in pediatric patients.

Material and Method: The sample comprises of standardized lateral cephalometric radiograph with the size of 100 subjects including male and female of 8-16 years of age who visited Department of Orthodontics and Dentofacial Orthopedics. All cephalometric radiographs were taken and the chosen hard and soft tissue calibrations like ramus length and nasolabial angle and CVM staging were evaluated and correlated using One-way ANOVA and Spearman correlation.

Result: CVM staging showed positive correlation with ramus length and age but no correlation with nasolabial angle. One-way ANOVA showed highly significant correlation of age, NLA and RL values between different CVM stages and Spearman correlation showed highly significant correlation of CVM with age, NLA and RL

Conclusion: Growth can also be predicted from ramus length and age of the patient as the study shows positive correlation between CVM staging and ramus length but no correlation with nasolabial angle. The calibrations are correlated to each other as $\text{cvm} \propto \frac{\text{ramus length}}{\text{nasolabial angis}}$ and $\text{cvm} \propto \text{age}$

Key-words: nasolabial angle, ramus length, cephalometric radiograph

Introduction:

Growth predication by skeletal maturation can be used to diagnose various growth disorders in pediatric patients and can also be used to monitor children on growth hormone therapy or those presenting on delayed or advanced stages of puberty that may need treatment.

The optimal time to begin growth modification for correction of skeletal malocclusions is during the pre-pubertal growth stage since it is a time when craniofacial changes are more likely to occur.[1] Identification of the teenage growth spurt in a patient has special therapeutic importance in the treatment plans for a number of dento-skeletal disharmonies (Lamparski, 1972; Proffit, 2002).[1] Every bone undergoes a series of changes while a child is growing, and while the timing of these changes varies from person to person depending on his or her individual biological clock, the sequence of changes is generally consistent for any given bone (Shamsher and Ijaz, 2005).[1]

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Numerous studies have shown that using a child's chronological age as a measure of maturity is unreliable (Hunter, 1966; Houston, 1979; Baccetti et al., 2002). Although chronological age is frequently used to assess a patient's place on their growth trajectory, it does not specifically address the differences in adolescence between the sexes and between individuals within the same sex in terms of timing, duration or extent.[1] Hassel and Farman (1995) demonstrated that predicting growth based on maturational development rather than chronological age can dramatically improve prediction accuracy by lowering physiologic variability among children of the same chronological age.[1]

Hand wrist radiographs have been used by Fishman (1981) to determine skeletal maturation because the changes seen in hand wrist radiograph are indicators of more general skeletal growth.[2]

Knowing the age of the cervical vertebral bones from the lateral cephalogram allows one to assess the skeletal maturation. It is well known that the morphology of the cervical vertebral bodies varies with growth (Mito et al., 2002, 2003). (Hassel and Farman, 1995; Baccetti et al., 2005; Flores et al., 2006; Uysal et al., 2006; AL-Hadlaq et al., 2007a) have proven the relationship between cervical vertebral maturation and skeletal maturation. Researchers have demonstrated a link between cervical vertebral maturation and skeletal maturation (Hassel and Farman, 1995; Baccetti et al., 2005; Flores et al., 2006; Uysal et al., 2006; AL-Hadlaq et al., 2007a). Additionally, it has been established that the mandible's peak growth coincides with cervical vertebral maturation (Franchi et al., 2000b; Baccetti et al., 2002). The formation and growth of face bones are interconnected processes. The mandibular body, mandibular angle, condylar process, coronoid process, symphysis and alveolar process are among the mandible's growth centres.[3]

Studies of nasal growth and morphology as well as assessments of changes in nasal and soft tissue form have all been done using lateral cephalometric radiographs.[4]

The present study ventures to explain a newer phenomenon of the soft tissue and hard tissue calibrations and their correlation with cervical vertebral maturation on lateral cephalogram of growing patients. The null hypothesis is that no relationship exist between mandibular growth on lateral cephalogram of growing patients and growth in facial soft tissues with maturation of cervical vertebrae on a lateral cephalogram.

Materials And Methods:

The sample comprises of standardized lateral cephalometric radiograph with the size of 100 subjects including male and female of 8-16 years of age who visited the Department of Orthodontics and Dentofacial Orthopedics. All cephalometric radiographs were taken and the chosen hard and soft tissue calibrations like ramus length and nasolabial angle and CVM staging were evaluated and correlated.

Inclusion criteria selected is

- Male and female patients of 8-16 years of age group.
- Patients who gave consent for the study.
- Patients with Class I, Class II, Class III malocclusion.
- Patients with concave, straight, convex profile.
- Patients who did not undergo any previous orthodontic treatment

Exclusion criteria selected is:

- Patients below 8 and above 16 years of age.
- Patients who did not give consent for the study.
- Patients with any systemic condition affecting growth
- Cephalometric calibrations used for this study:

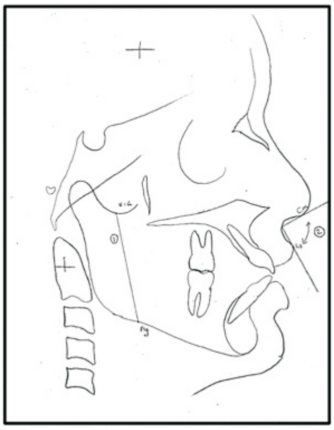


Figure 1: Figure showing ramus length (sigmoid notch to antegonial notch) and nasolabial angle (angle between tangent to Cm and tangent to Ls)

Ramus length (mm): Linear measurement from sigmoid notch (SIG) to antegonial notch (Ag).[3]

Nasolabial angle: Angle between Cm (Columella) tangent to Ls (Labial superioris) tangent.[3]

Cervical stage 1	(CS 1)	The lower borders of all the three vertebrae are flat. The bodies of both C3 and C4 are trapezoid in shape. the peak in mandibular growth will occur not earlier than two years after this stage
Cervical stage 2	(CS 2)	Concavity at the lower borders of both C2 is present. The bodies of C3 and C4 are still trapezoid in shape. the peak in mandibular growth will occur on average one year after this stage
Cervical stage 3	(CS 3)	Concavities at the lower borders of C2, and C3 are present. The bodies of both C3, C4 are either trapezoid or rectangular horizontal in shape. the peak in mandibular growth will occur during one year after this stage
Cervical stage 4	(CS 4)	The concavities at the lower borders of C2, C3, and C4 are still present. The body of C3 and C4 are rectangular horizontal in shape. the peak in mandibular growth has occurred within one or two years before this stage
Cervical stage 5	(CS 5)	The concavities at the lower borders of C2, C3, and C4 still are evident. At least one of the bodies of C3 and C4 is square in shape. If not squared, the body of the other cervical vertebra is rectangular horizontal. The peak in mandibular growth has occurred not later than one year before this stage
Cervical stage 6	(CS 6)	The concavities at the lower borders of C2, C3, and C4 still are evident. The bodies of C3 and C4 are rectangular vertical in shape. The peak in mandibular growth has ended at least 2 years before this stage

Figure 2: Figure showing maturation stages of cervical vertebrae[1]

CVM stage: based on the developmental stages of cervical vertebrae as ideally given by Hassel and Farman.[1]

Data was analyzed using SPSS version 22. Intragroup and intergroup comparisons were performed using One way ANOVA test and spearman correlation.

Result:

Table 1: Comparison of Age, NLA and RL values between different CVM stage

CVM	Age	Test value	NLA	Test value	RL	Test value
Cs2	11.52±0.51	F=61.66	101.11±10.80	F=29.55	41.82±3.08	F=37.24
Cs3	13.00±0.15	P	104.00±0.98	P	51.00±0.00	P
Cs4	13.60±1.03	=0.001**	120.20±10.09	=0.001**	47.80±3.35	=0.001**
Cs5	14.30±0.47		107.00±0.84		46.57±3.39	
Cs6	16.00±0.00		97.00±0.00		57.00±0.00	

One way ANOVA test, ** Highly significant

Cervical vertebral maturation (CVM), Nasolabial angle(NLA), Ramus length(RL)

Comparison of age, nasolabial angle and ramus length is done using One-way ANOVA test which has shown highly significant results with the F value being 61.66, 29.55 and 37.24 for age, nasolabial angle and ramus length respectively. P value shown by the comparison is 0.001, 0.001 and 0.001 for age, nasolabial angle and ramus length respectively. (Table 1)

Table 2: Correlation of CVM with Age, NLA and RL

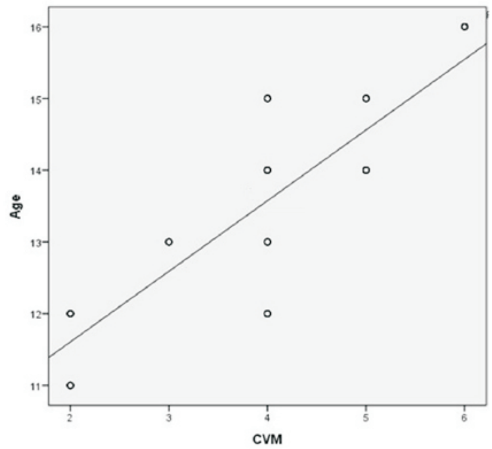
Parameters		CVM
Age	Correlation Coefficient (rho)	0.792
	Sig. (2-tailed)	0.001**
NLA	Correlation Coefficient (rho)	-.070
	Sig. (2tailed)	.491

Spearman Correlation, ** Highly Significant

Cervical vertebral maturation(CVM), Nasolabial angle(NLA), Ramus length(RL)

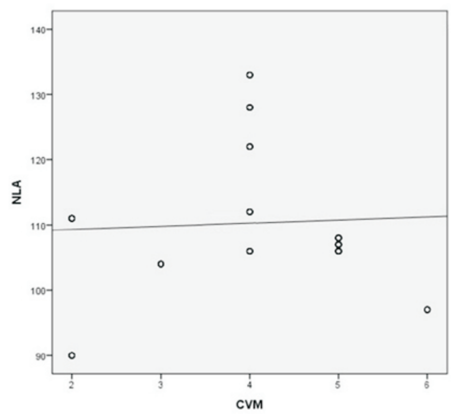
Correlation of CVM with age, NLA and RL is done using Spearman correlation, which showed highly significant results. (Table 2)

Graph 1: Correlation between CVM and Age



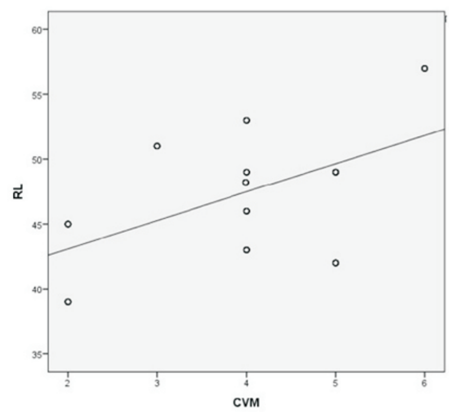
Maturation of Cervical vertebrae has shown direct proportionality with the age of growing patients as shown in (graph 1).

Graph 2: Correlation between CVM and NLA



The result also found that Nasolabial angle was not correlated with CVM. (Graph 2)

Graph 3: Correlation between CVM and RL



Ramus length showed positive moderate correlation with CVM with correlation Coefficient rho (ρ) value 0.388 and P value 0.001 . (Table 2, Graph 3)

Discussion:

Development of the child depends on individual's differences in the magnitude of growth with different individuals requiring different time factor to achieve maturation.[10] Hence it is important for the clinician to identify the stage of maturation of an individual to make a suitable decision on the timing of the treatment options.[10]

At Case Western Reserve University, Hassel and Farman[19] examined left hand-wrist and lateral cephalometric radiographs from the Bolton-Brush Growth Study in order to create an index based on the lateral profiles of the second, third, and fourth cervical vertebrae.

O'Reilly and Yanniello[20] examined annual lateral cephalometric radiographs of 13 Caucasian girls between the ages of 9 and 15 to examine the relationship between cervical vertebral maturation and changes in mandibular growth. They discovered statistically significant increases in mandibular length, corpus length, and ramus height in relation to particular cervical vertebral maturation stages using the Lamparski method.[21].

Posen reported that 90% of nasal bone development is usually completed by the age of 13 years, at which age male and female nasal bone growth patterns are fundamentally similar.[3] Thus, it can be concluded that facial bone development had probably stabilized at the age of 18 years.[3]

We agree with these studies and believe that the antegonial notch is an essential growth center.[3] The antegonial notch is the attachment site of the masseter and medial pterygoid muscles; hence, it is strongly affected by muscular movements.[3] On the basis of the physiology of mandibular bone development, our study used the antegonial notch as the separation growth point for the mandibular ramus and body.[3]

Our study showed similar results that the ramus length increases with age and shows maturation like cervical vertebrae and development in nasolabial angle is seen at the certain age as the nose growth occurs.

The factors affecting Cervical Vertebral Maturation (*CVM*) was compared using One way ANOVA test. Age, Nasolabial angle (NLA) and Ramus length (RL) had shown positive correlation with CVM.

The mean age increases from Cs2 to Cs6. The age in Cs2 patients was 11.52 years, in Cs3 patients was 13.00±0.15 years, in Cs4 patients was 13.60±1.03 years, in Cs5 patients was 14.30±0.47years and , in Cs6 patients was 16.00±0.00 years. One way ANOVA test found significant association between CVM and Age with F value 61.66 and p value 0.001.

The mean Nasolabial Angle increases till Cs4 then decreases till Cs6. Its value in Cs2 patients was 101.11º±10.80º, in Cs3 patients was 104.00º±0.98º, in Cs4 patients was 120.20º±10.09º, in Cs5 patients was 107.00º±0.84º years and in Cs6 patients was 97.00º±0.00º. One way ANOVA test found significant association between CVM and Age with F value 29.55 and p value 0.001. The mean Ramus length value in Cs2 patients was 41.82±3.08 mm, in Cs3 patients was 51.00±0.00 mm, in Cs4 patients was 51.00±0.00 mm, in Cs5 patients was 47.80±3.35 mm and in Cs6 patients was 57.00±0.00 mm. One way ANOVA test found significant association between CVM and Age with F value 37.24 and p value 0.001. (Table 1)

Spearman Correlation was performed to find out the relation of CVM with Age, Nasolabial angle and Ramus length. Age had shown strong positive correalation with Cervical Vertebral Maturation (*CVM*) with correlation Coefficient rho (ρ) value 0.792 and p value 0.001. (Table 2, Graph 1)

Conclusion:

Growth predication by skeletal maturation can be used to diagnose various growth disorders in pediatric patients and can also be used to monitor children on growth hormone therapy or those presenting on delayed or advanced stages of puberty that may need treatment. Orthodontic treatment plan depends on the growth potential of the growing individual and the amount of residual growth which is important to assess the patient's stage of maturation. By using lateral cephalogram the stage of maturation can be assessed by using cervical vertebral maturation stages and ramus length. The CVM stage showed strong correlation with the age of the individual growing patient and highly significant results with the ramus length when compared with different statistical methods. Also the CVM stages showed no correlation with the nasiolabial angle of the growing patients. The calibrations are correlated to each other as

References:

1. Baidas L. Correlation between cervical vertebrae morphology and chronological age in Saudi adolescents. King Saud University Journal of Dental Sciences. 2012 Jan 1;3(1):21-6.

2. Fishman LS. Radiographic evaluation of skeletal maturation: a clinically oriented method based on hand-wrist films. The Angle Orthodontist. 1982 Apr;52(2):88-112.
3. Chen HS, Hsiao SY, Lee KT. Analysis of Facial Skeletal Morphology: Nasal Bone, Maxilla, and Mandible. BioMed Research International. 2021 May 25;2021.
4. Begg RJ, Harkness M. A lateral cephalometric analysis of the adult nose. Journal of oral and maxillofacial surgery. 1995 Nov 1;53(11):1268-74.
5. Van der Heijden P, Korsten-Meijer AG, van der Laan BF, Wit HP, Goorhuis-Brouwer SM. Nasal growth and maturation age in adolescents: a systematic review. Archives of Otolaryngology–Head & Neck Surgery. 2008 Dec 15;134(12):1288-93.
6. Baccetti, T., Franchi, L., McNamara, J.A., 2002. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod. 72 (4), 316–323.
7. Basaran, G., Ozer, T., Hamamci, 2007. Cervical vertebral and dental maturity in Turkish subjects. Am. J. Orthod. Dentfacial Orthop. 131 (4), e13–20, 447.
8. Başaran G, Ozer T, Hamamci N. Cervical vertebral and dental maturity in Turkish subjects. Am J Orthod Dentofacial Orthop. 2007 Apr;131(4):447.e13-20. doi: 10.1016/j.ajodo.2006.08.016. PMID: 17418707.
9. Tofani MI. Mandibular growth at puberty. American Journal of Orthodontics. 1972 Aug 1;62(2):176-95.
10. **Wani A, Chalkoo A, Tariq S, Bedar** A Assessment of bone age by cervical vertebral dimensions in lateral cephalometric radiographs, JOOM, 2018;4(3),160-63
11. Krogman, W. M.: The concept of maturity from a morphological viewpoint, Child Dev. 21: 25, 1950.
12. Richey, H. G.: The relation of accelerated normal and retarded puberty on the height and weight of school children, Monograph of the Society for Research in Child Development, vol. 2, No. 1, 1937.
13. Abernethy, E. M.: ReIationship between mental and physical growth, Monograph of the Society for Research in Child Development, vol. 1, No. 7, 1936.
14. Todd T, Pyle SI. Quantitative study of the vertebral column. Am J Phys Anthropol. 1928;12:321.
15. Lanier R. Presacral vertebrae of white and Negro males. Am J Phys Anthropol. 1939;25:341–417.
16. Taylor JR. Growth of human intervertebral discs and vertebral bodies. J Anat. 1975;120:49–68.
17. Gray H, Clemente CD. Anatomy of the Human Body. 30th ed. Philadelphia, Penn: Lea & Febiger; 1985.
18. Bick E, Copel J. Longitudinal growth of the human vertebrae. J Bone Joint Surg (Am). 1950;32A:803–813.
19. Hassel B, Farman A. Skeletal maturation evaluation using cervical vertebrae. Am J Orthod Dentofacial Orthop. 1995;107:58– 66.
20. O'Reilly M, Yanniello GJ. Mandibular growth changes and maturation of cervical vertebrae–a longitudinal cephalometric study. Angle Orthod. 1988;58:179–184.
21. Lamparski DG. Skeletal Age Assessment Utilizing Cervical Vertebrae [Master's thesis]. Pittsburgh, Penn: Department of Orthodontics, The University of Pittsburgh; 1972.