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CEPHALOMETRIC EVALUATION OF CERVICAL VERTEBRAL COLUMN MORPHOLOGY AND CERVICAL VERTEBRAL MATURATION IN SUBJECTS WITH VERTICAL AND HORIZONTAL GROWTH PATTERN

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ABSTRACT

Objective: To assess the morphology and maturation of the cervical vertebrae in patients with different vertical growth pattern.

Subjects and methods: one hundred and fifty lateral cephalometric radiographs were collected and classified into three equal groups. Group one representing vertical growth pattern (SN\Go-Gn≥35),group two representing horizontal growth pattern (SN\Go-Gn≤28) and group three is the control group with average growth pattern (SN\Go-Gn=30±2). The cervical vertebrae morphology was compared between the three groups using linear and angular cephalometric measurements. The cervical maturation will be assessed according to the CVM staging system.

Results: Significant differences in head posture were found in relation to cervical column (SN/CVT°, SN/OPT°) between the studied groups ($p<0.001$). Linear vertical measurement between fourth cervical vertebra and anterior cranial base (S-CV4) was significantly greater by 5.25mm in horizontal than in vertical group. Group one (vertical)showed the greatest cervical vertebral maturity, whereas group two(horizontal) showed the least cervical vertebral maturity.

Conclusions: The head was more extended in relation to cervical vertebral column in subjects with average growth pattern than those with horizontal and vertical growth pattern. Individuals with horizontal growth pattern showed delayed skeletal maturation when compared to vertical growers.

KEYWORDS: Cervical vertebral maturation, head posture, growth pattern.

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INTRODUCTION

The cervical spine is considered as an area of interest in orthodontics. Various studies have been done to assess if the cervical vertebrae morphology seem to be affected by age, head posture, skeletal growth pattern and presence of congenital anomalies. Regarding head posture, in 1976, Solow and Tallgren [(1)] found a relationship between craniofacial structure and head posture. Shape and growth of the mandible, angulation of cranial base and head posture are found to be affected by dimensions of first cervical vertebra (CV_1) horizontally and vertically [(2)].

Cone beam computed tomography was used by Watanabe et al in 2010[(3)] to describe the morphology of cervical vertebra in persons with various sagittal jaw relationships. Additionally, lateral cephalograms have been utilised to evaluate natural head position using the cervical vertebral column as a reference structure. The relationship between maxillomandibular growth and cervical vertebral maturation (CVM) has received more attention over the past three decades. Beginning in the 1970s, several attempts at cervical vertebrae analysis were performed, with the most popular one being modified by Bacetti et al.[(4)]. Mandibular growth alterations in growing subjects and the stages of cervical vertebrae maturation (CVM) have both been shown to be reliable indicators of mandibular skeletal maturity[(5)]. According to Salagnac et al.[(6)], the mandible, upper face, and cervical spine all grew vertically at associated anatomical and physiological rates. This study aimed to evaluate cervical vertebrae morphology and cervical vertebral maturation in different growth patterns.

SUBJECTS AND METHODS

This study was performed after receiving the approval of the ethical committee of Faculty of Dentistry, Tanta University (#-RORTH-10-22-2). The present study was done on lateral cephalometric radiographs of 150 growing subjects aged 8-10 years (75 males and 75 females) randomly selected from the records of patients under treatment in Orthodontic Department, Faculty of Dentistry, Tanta University.

Based on the SN/G -Gn, 150 cephalograms was divided into three equal sized groups; Group one representing control group with average growth pattern (SN/Go-Gn=30±2), group two representing horizontal growth pattern (SN/Go-Gn≤28) and group three is the vertical growth pattern (SN/Go-Gn≥35)

The following criteria were used to select the subjects: had acceptable occlusions, no craniofacial syndromes, no history of trauma that may affect craniofacial growth, no systemic diseases has effect on muscles or joints and no past orthodontic and orthopedic treatment and no anomalies of the vertebrae in radiographs.

Angular measurements were made on each cephalometric radiographs to identify the growth patterns. FH-SN angle was measured and known as angle alpha (α). On consecutive cephalograms, a line was drawn through S at an angle to SN that was equivalent to angle (α), and this angle was referred to as the FH estimated angle (FHe). Vertical position of CV4 from S point (CV4-S) was measured in millimeters along this vertical axis (fig1).

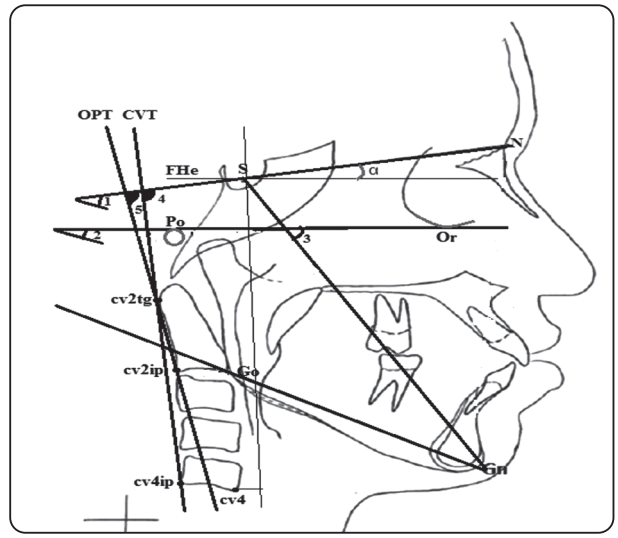

Fig. (1) Angular and Linear measurements 1- SN/Go Gnº. 2- FMPAº. 3- Y axisº. 4- SN/CVTº 5- CVT/OPTº. 6- S- cv4 mm

The cervical column morphology was assessed by measuring two angles: 1) SN/CVTº between SN line and (CV4ip and CV2tg form a tangent to the cervical vertebrae). 2) SN/OPTº between SN line and OPT (odontoid process tangent via CV2ip and CV2tg) (fig1)

The CVM code staging method was used to determine how mature the cervical vertebrae were as described by Baccetti et al [7].

All variables were measured after a period of two weeks and no significant difference was found between the 2 sets of recordings.

The method error was calculated by Dahlberg's formula [8].

Statistical analysis

All measurements were calculated, tabulated and statistically analyzed using SPSS version (SPSS, Inc; Chicago, III).

RESULTS

This study consisted of 75 females and 75males (each group consisted of 25 males and 25 females).

In control group, only S-CV4 compared to girls, were substantially greater in boys. ($p < 0.05$) while girls recorded higher values regarding to other variables (Table 1).

Otherwise CVM, did not significantly differ between boys and girls in the horizontal group, while, S-CV4, SN/CVTº, SN/OPTº significantly differs between boys and girls. S-CV4 was greater in boys than in girls, while the reverse was recorded regarding SN/CVTº and SN/OPTº (Table 2).

Regarding the vertical group CVM and SN/CVTº compared to boys, they were substantially higher in girls. On the other hand, S-CV4 was significantly greater in boys than in girls (Table 3).

In Table 1-3, the mean linear measurement of S-CV4 showed significant greater values for boy than girls in all group. While, the head posture in relation to cervical column (SN/CVTº, SN/OPTº) was greater in girls than in boys in all groups.

Statistical analysis of skeletal maturity (CVM) showed significant difference between patients with normal, horizontal and vertical growth pattern. The cervical vertebral maturity was highest in the vertical group, whereas it was lowest in the horizontal group (Table 4).

TABLE (1) Comparison of Mean CVM, S-CV4mm, SN/CV4º and SN/OPTº among boys and girls in control group:

Control group		Range			Mean	±	S. D	t. test	p. value
CVM	Boy	3	–	4	3	±	0.50	3.645	0.001*
	Girl	2	–	4	3.48	±	0.78		
S-CV4 mm	Boy	85	–	110	98.2	±	6.84	2.682	0.009*
	Girl	90	–	108	89.7	±	21.34		
SN/CV4º	Boy	92	–	119	106.16	±	7.73	0.878	0.382
	Girl	97	–	124	107.46	±	7.06		
SN/OPTº	Boy	90	–	117	103	±	8.32	0.244	0.808
	Girl	94	–	117	103.38	±	7.23		

TABLE (2) Comparison of Mean CVM, S-CV4mm, SN/CV4° and SN/OPT° among boys and girls in horizontal group:

Horizontal group		Range			Mean	±	S. D	t. test	p. value
CVM	Boy	1	–	3	1.56	±	0.70	0.664	0.508
	Girl	1	–	3	1.66	±	0.80		
S-CV4 mm	Boy	90	–	111	101	±	5.16	2.071	0.041*
	Girl	90	–	108	98.8	±	5.45		
SN/CV4°	Boy	92	–	107	100.1	±	4.81	3.196	0.002*
	Girl	87	–	114	103.68	±	6.29		
SN/OPT°	Boy	86	–	105	95.9	±	5.27	3.424	0.001*
	Girl	83	–	106	99.7	±	5.82		

TABLE (3) Comparison of Mean CVM, S-CV4mm, SN/CV4° and SN/OPT° among boys and girls in vertical group:

Vertical group		Range			Mean	±	S. D	t. test	p. value
CVM	Boy	1	–	3	1.68	±	0.59	2.769	0.007*
	Girl	1	–	4	2.16	±	1.08		
S-CV4 mm	Boy	95	–	97	96.36	±	0.69	11.509	0.001*
	Girl	90	–	98	92.94	±	1.98		
SN/CV4°	Boy	10	–	104	87.52	±	23.58	2.504	0.014*
	Girl	85	–	104	96.1	±	5.58		
SN/OPT°	Boy	82	–	102	92.02	±	5.90	1.024	0.308
	Girl	83	–	101	93.18	±	5.42		

TABLE (4) Comparison of skeletal maturity (CVM) among subjects with normal, horizontal and vertical growth pattern:

CVM	Control	Horizontal	Vertical
Range	2 – 4	1 – 3	1 – 4
Mean ± SD	1.92 ± 0.90	1.61 ± 0.75	3.24 ± 0.70
F. test		**121.338**	
P. value		0.001*	
Control & horizontal	**Control & vertical**		**Horizontal & vertical**
0.001*	0.001*		0.006*

The mean linear measurement of S-CV4 showed significant difference between the groups. It was 93.95±16.33, 99.90±5.40, 94.65±2.27 in control, horizontal and vertical group respectively. It was significantly greater by 5.25mm in horizontal than in vertical group (Table 5).

TABLE (5) Comparison of mean linear measurement of S-CV4 among the groups:

S-CV4 mm	Control	Horizontal	Vertical
Range	9 – 110	90 – 111	90 – 98
Mean ± SD	93.95±16.33	99.90±5.40	94.65±2.27
F. test		**10.538**	
P. value		0.001*	
Control & horizontal	**Control & vertical**		**Horizontal & vertical**
0.001*	0.622		0.001*

Significant differences in head posture in relation to the cervical column were observed. (SN/CVTº, SN/OPTº) between the studied groups. The head in relation to cervical vertebral column was more extended in subjects with average growth pattern than those with horizontal and vertical growth pattern (Table 6, 7).

TABLE (6) Comparison of SN/CVTº between group I, II and III:

SN/CVTº	Control	Horizontal	Vertical
Range	92 – 124	87 – 114	10 – 104
Mean ± SD	106.81±7.39	101.89±5.85	91.81±17.58
F. test		**44.067**	
P. value		0.001*	
Control & horizontal	**Control & vertical**		**Horizontal & vertical**
0.003*	0.001*		0.001*

TABLE (7) Comparison of SN/OPTº between group I, II and III:

SN/OPTº	Control	Horizontal	Vertical
Range	90 – 117	83 – 106	82 – 102
Mean ± SD	103.19±7.76	97.80±5.84	92.60±5.66
F. test		**66.552**	
P. value		0.001*	
Control & horizontal	**Control & vertical**		**Horizontal & vertical**
0.001*	0.001*		0.001*

DISCUSSION

Anomalies of the cervical morphology can be found in healthy people with neutral occlusion and normal craniofacial morphology, in addition to subjects suffering from craniofacial syndromes, deviating craniofacial morphology and significant malocclusion features. The aim of this study was to evaluate cervical vertebral column morphology and cervical vertebral maturation in subjects with vertical and horizontal growth patterns. The present study was done on lateral cephalometric radiographs of 150 growing subjects aged 8-10years.

Cephalograms were divided into three equal sized groups; Group one that represent vertical growth pattern, group two representing horizontal growth pattern and group three that was the control group according to SN/G- Gn. To determine the growth patterns, angular measurements were taken on each cephalometric radiograph. Results revealed that: in the horizontal group; no significant difference was found in CVM between boys and girls; however, a significant difference was found in S-CV4, SN/CVT, and SN/OPTº between boys and girls. S-CV4 was higher in males than in girls, although SN/CVT and SN/OPTº results were the reverse. In the control group CVM and S-CV4 values were significantly higher in boys than in girls. In regards of the vertical group, girls had significantly higher CVM and SN/CVTº than boys. S-CV4 was, however, significantly greater in boys than in girls. Significantly higher values were shown by the S-CV4 mean linear measurement. In contrast, boys in all groups had a higher head posture related to the cervical column (SN/CVT, SN/OPTº).

Statistical study found significant differences in skeletal maturity (CVM) across patients with normal, horizontal, and vertical growth patterns. The cervical vertebrae in the vertical group were the most mature, whereas those in the horizontal group were the least mature. There was a significant difference between the groups as shown by the mean linear S-CV4 measurement. In the horizontal group, it was much higher than in the vertical group. Between the studied groups, there were substantial differences in posture of the head in regard to the cervical column (SN/CVTº, SN/OPTº). Comparing patients with average growth patterns to those with vertical and horizontal patterns of growth, the head was more expanded in relation to the cervical vertebral column.

Evaluation of the morphology cervical vertebral column and cervical vertebral maturation has been studied by many authors in different manners. Many of these studies go in line with our results in that a significant relation (difference) was found between CVM and other parameters to be studied. Conebeam computed tomography was used to study cervical vertebra morpholoy in different antero-posterior jaw relationships. Heights of Atlas dorsal arch were significantly lower in Class II. The conclusion was that anteroposterior skeletal pattern affects height of atlas dorsal arch of cervical vertebrae [(9)]. Results of a study done by Arntsena and Sonnesenb coincide with those of the present study. They evaluated at how pre-orthodontic children with Class II malocclusion and horizontal maxillary overjet related to morphology of cervical column , craniofacial morphology, and head posture. CVM was examined and related to craniofacial morphology and head posture. They concluded that the skeletal overjet group, as compared to the dentoalveolar overjet group, had a significant deviation in cervical vertebral column morphology more frequently. They added that a significant association was found between large cranial base angle and partial cleft patients [(10)].

The second cervical vertebra was used by Gupta et al. (2016) to analyse and compare the relationship between the cervical spine and the face in subjects with horizontal and vertical growth patterns. It was correlated with the anterior cranial base, maxilla, and mandible in adults with different horizontal and vertical growth patterns. The growth pattern of the mandible and the morphology of the cervical vertebrae were shown to be significantly correlated[(11)].

In a 2013 study, Torres et al. examined whether cervical vertebrae maturation index (CVMI) could be used to determine development stage when the head was inclined upward or downward.

Results revealed a difference in evaluation of cervical vertebrae maturation index on cephalograms in natural head position (NHP) compared to radiographs taken with inclinations [(12)].

Sonnesen; 2010 summarized studies that done recently on morphological deviations of CVM with craniofacial morphology and posture of head in patients suffering from obstructive sleep apnoea and nonsyndromic patients. He concluded that function and development of the craniofacial morphology are related to the fusion of the cervical vertebrae [(13)].

Kim et al; 2014 studied morphology of the cervical vertebral column and anterior open bite in head posture. There were no significant differences in the cervical vertebral column's morphology between groups with skeletal and dentoalveolar open bites. While there were significant differences in head posture amongst the groups in terms of their relationships to craniofacial dimensions. Children's respiratory disease as a contributing factor may indicate this significant difference [(14)]. On the other hand, Naderi et al; 2022 concluded that CVM stages 2, 3, and 4 failed to achieve an adequate diagnostic reliability in identifying the mandibular development peak [(15)].

CONCLUSIONS

- In comparison to patients with horizontal and vertical development patterns, subjects with average growth patterns had a longer neck relative to the cervical vertebral column.
- Individuals with horizontal growth pattern showed delayed skeletal maturation when compared to vertical growers.
- Compared to boys, girls displayed more skeletal maturity
- Compared to males, girls had a more extended head posture with regard to the cervical vertebral column.

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