

12-30-2020

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Recommended Citation

Kale, B., & Buyukcavus, M. Effect of Craniofacial Growth Pattern on Head Posture. *J Dent Indones.* 2020;27(3): 144-150

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ORIGINAL ARTICLE

Effect of Craniofacial Growth Pattern on Head Posture

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ABSTRACT

Head posture refers to the upright position of the head of a standing or sitting subject. The literature reports that head posture is affected by many factors. **Objective:** To evaluate differences in head posture according to craniofacial growth pattern. **Methods:** A total of 163 individuals (83 females and 80 males) were included in this study. Patients were divided into three groups according to ANB angle as Class I, Class II, and Class III, and each group was divided further into three subgroups according to SN/GoGn angle as hyperdivergent, normodivergent, and hypodivergent. The patients were compared in terms of head posture measurements. Two-way ANOVA was used to evaluate the main and interactive effects of vertical growth pattern and malocclusion type on the head posture of the patients. Results were considered statistically significant at $p < 0.05$. **Results:** No statistically significant difference between malocclusion and face-type groups was observed in all head posture measurements ($p > 0.05$). **Conclusion:** Head posture is similar among subgroups of different malocclusion types separated by vertical growth pattern.

Key words: cephalometry, head posture, malocclusions, vertical growth pattern

How to cite this article: Kale B, Buyukcavus MH. Effect of craniofacial growth pattern on head posture. J Dent Indones. 27(3):144-150

INTRODUCTION

Head posture and facial morphology are affected by respiratory functions during growth and development.¹⁻⁶ Postural adaptation of the hyoid bone and tongue is not always sufficient to solve airway obstruction problems. Extension of the head and neck may occur as a functional response to airway obstruction.^{3,7} Schwartz first introduced the relationship between head posture and craniofacial morphology in 1928. According to the author, extension of the head, especially during sleep, causes Class II malocclusions.⁸ In 1982, Rocarbado et al. presented strong evidence of the relation between malocclusion and head posture.⁹ Woodside et al. found that the prevalence of mandibular anterior crowding is higher in impaired nose breathers than in normal breathers.¹⁰ Liu et al. reported that distal occlusion and increased overjet are caused by a flexed head posture.¹¹ Basheer et al. observed postural changes resulting from total nasal obstruction among 25 adult individuals before and 1 hour after total nasal obstruction and found statistically significant differences in the spacing of the lips, lower jaw, and hyoid bone position.¹²

Björk revealed the relationship between cranial base and posture by observing that individuals with retrognathia tend to raise their heads up whereas individuals with prognathies tend to bow their heads forward.¹³ In his cephalometric study, Bench discussed the relationship between facial form and cervical spine length and curvature. The scholar found that the vertical growth of the face after puberty is closely related to neck growth and that the cervical column is flat and long in dolichosphate individuals but inclined forward in brachiocephalus individuals.¹⁴

Solow and Kreiborg explained the relationships between airway obstruction, postural changes caused by soft tissue tension, and changes in craniofacial morphology by using the “soft tissue tension” hypothesis. The researchers argued that postural changes due to airway obstruction disturb the balance of forces around the skeleton and, as a result, cause changes in craniofacial morphology.¹⁵ Solow and Tallgren explained the relationship between head posture and craniofacial morphology as follows.¹⁶ During extension of the head relative to the cervical column, the anteroposterior

craniofacial size decreases, the height of the anterior surface decreases, the height of the anterior face increases, facial retrognathism occurs, the slope of the mandible relative to the anterior cranial base increases, the angle of the cranial base increases, and the nasopharyngeal airway decreases. During flexion of the head, the authors observed an increase in anteroposterior craniofacial size, an increase in the height of the posterior surface, a decrease in the height of the anterior face, facial prognathism, a decrease in the angle of the mandible compared with the anterior cranial base, an increase in the angle of the cranial base, and an increase in the nasopharyngeal airway.

Previous studies associated head posture with height, ethnic difference, gender, age, facial morphology, dimensions, shape, nasorespiratory function, temporomandibular dysfunction, and bruxism.^{17,18} The relationships between head posture and skeletal–dental malocclusions, such as crowding in the maxillary and mandibular dental arches, spacing, overbite, crossbite, midline discrepancies, skeletal, and molar, have been studied.^{18,19} Some authors have reported that nasorespiratory dysfunction and malocclusions cause changes in vertical growth patterns.^{18,20} Several studies have also examined the effects of different variables on head posture. However, both the vertical growth pattern and the malocclusion type are considered, and it is not within the scope of our study information evaluated according to the craniofacial growth pattern. Therefore, in the present study, we aimed to compare head positions among subgroups of healthy patients with different malocclusions (i.e., Class I, Class II, and Class III) separated by different vertical growth patterns (i.e., hypodivergent, normodivergent, and hyperdivergent).

METHODS

A retrospective study of untreated patients with orthodontic malocclusion at the Oral and Dental Health Treatment Center, Antalya Bilim University, Turkey was conducted. Ethical approval for this retrospective study was obtained from Clinical Research Ethics Committee of University of Health Sciences Antalya Training and Research Hospital (12.03.2020-5/9), and informed consent was obtained from the parents of the patients included in this work. This study consisted of patients divided into three subgroups according to their vertical growth pattern (i.e., hypodivergent, normodivergent, and hyperdivergent) with skeletal Class I, Class II, and Class III malocclusions.

The sample size was calculated on the basis of a power analysis using G* Power (version 3.0.10, Kiel, Germany) for superior airway space at an α error probability of 0.05 and a power of 80%. The power analysis showed that a minimum of 17 individuals

was required for each subgroup. More individuals were included in the study to increase its power and compensate for possible losses.

The inclusion criteria are the absence of any craniofacial anomaly or systemic disorder, no airway pathologies, adequate imaging quality of cephalometric radiographs, and no previous orthodontic treatment. Patients whose head posture was erroneous during radiographic exposure, patients over 17 years of age, and patients with artifacts on their radiographs were excluded from the study. Patients who met the inclusion criteria in accordance with the necessary information derived from the anamnesis forms were determined without evaluation of their radiographic findings. The participants were then randomly divided into groups according to their analysis at the beginning of the treatment, regardless of head posture.

Out of the 243 patients included in the evaluation, 80 patients were excluded from the study. A total of 163 individuals (83 females and 80 males) were included in the study. The radiographs of the patients were exclusively obtained from the device in our clinic for orthodontic patients. During radiograph collection, the head was fixed with a cephalostat, and exposure was made in the natural head posture with the help of a mirror located opposite the Orthophos SL 3D[®] (Dentsply–Sirona, Bensheim, Germany) device (85 kV, 8 mA, 15 s exposure time). In addition, the patients' heads were fixed with a cephalostat, and radiographs were obtained while the teeth were in centric occlusion. This standardization was routinely performed for each patient, and patients who kept their head under extension or flexion during radiography were excluded from the study.

During grouping according to craniofacial growth pattern, ANB angles were used to detect skeletal malocclusions in the sagittal direction and SN/GoGn angles were used to determine vertical growth patterns. Patients were divided into three groups according to ANB angle as Class I ($0^\circ < \text{ANB} < 4^\circ$), Class II ($\text{ANB} > 4^\circ$), and Class III ($\text{ANB} < 0^\circ$). Each group was further divided into three subgroups according to SN/GoGn angle as hyperdivergent ($\text{SN/GoGn} > 38^\circ$), normodivergent ($26^\circ < \text{SN/GoGn} < 38^\circ$), and hypodivergent ($\text{SN/GoGn} < 26^\circ$).

The patients were compared according to their skeletal malocclusion classification and vertical growth pattern, and the nine subgroups were compared in terms of head posture measurements.

Cephalometric analysis

Lateral cephalometric radiographies (LCR) were taken while in orthoposition, a postural recording method defined by Molhave (1958) and modified by Solow and Tallgren.²¹ During LCR collection using standard

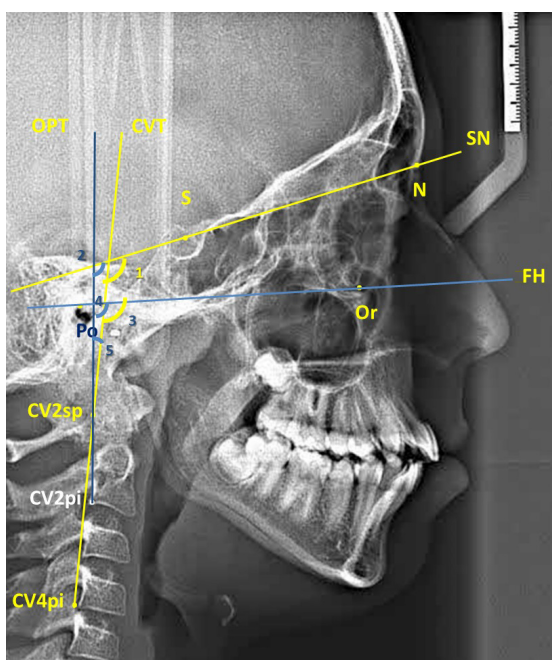


Figure 1. Head posture measurements used in this study

methods, patients were asked not to swallow or move their head and tongue. Gender differences in LCR head posture dimensions were determined. Radiographs were traced and measured by the same investigator (BK). The cephalometric angular measurements, landmarks, and reference lines are shown in Figure 1. Linear measurements used in the study are in the Dolphin Imaging (Patterson Technology, Chatsworth, CA, USA) were performed on digital lateral cephalometric films after digital calibration. In this study, 35 cephalometric points, 8 cephalometric planes, and 5 head posture measurements were used.

SN-CVT: The angle between the anterior cranial base (SN) and the cervical vertebrae tangent

SN-OPT: The angle between the anterior cranial base (SN) and the odontoid process tangent (OPT)

FH-CVT: The Frankfurt horizontal (FH) and cervical vertebrae tangent (CVT)

FH-OPT: The Frankfurt horizontal (FH) and odontoid process tangent (OPT)

CVT-OPT: The cervical vertebrae tangent (CVT) and the odontoid process tangent (OPT)

Statistical analysis

The Kolmogorov–Smirnov test was used to determine whether the data had a normal distribution. Because the parameters evaluated in this study were generally distributed homogeneously among the subgroups, parametric tests were used. The gender distribution of the patients was compared using Pearson’s chi-squared test. Two-way ANOVA (generalized linear model [GLM]) was used to evaluate the main and interactive effects of two factors among patients subdivided according to vertical growth pattern and malocclusion type. Tukey’s post-hoc tests were used

for bilateral comparisons of significant parameters. The error margin of the measurements was determined from 45 randomly selected films obtained from 163 lateral cephalometric films by the same researcher after the first measurements. Cronbach α coefficients were determined for each measurement. Repeatability coefficients were found to be high for each measurement ($\alpha \geq 0.863$), and the results of a paired *t*-test showed that the data were free of systematic error ($p > 0.05$). The SPSS package for Windows (version 21.0; SPSS Inc., Chicago, IL, USA) was used for data analysis. Results were considered statistically significant at $p < 0.05$.

RESULTS

The distribution of patients grouped according to craniofacial growth pattern (i.e., malocclusion type and vertical growth pattern), chronological age, and sex is shown in Table 1. The mean age of 55 patients (29 females and 26 males) with Class I malocclusion was found to be 14.45 ± 2.35 years. In this group, 31% of the patients were hypodivergent (17 patients; 9 females, 8 males; mean age, 14.61 ± 2.01 years), 34% of the patients were normodivergent (19 patients; 10 females, 9 males; mean age, 14.36 ± 2.43 years), and 34% of the patients were hyperdivergent (19 patients; 10 females, 9 males; mean age, 14.39 ± 2.43 years).

The mean age of 55 patients (28 females and 27 males) with Class II malocclusion was found to be 14.43 ± 2.19 years. In this group, 33% of the patients were hypodivergent (18 patients; 9 females, 9 males; mean age, 14.39 ± 2.17 years), 31% of the patients were normodivergent (17 patients; 9 females, 8 males; mean age, 14.43 ± 2.08 years), and 36% of the patients were hyperdivergent (20 patients; 10 females, 10 males; mean age, 14.48 ± 2.31 years).

The mean age of 53 patients (26 females and 27 males) with Class III malocclusion was found to be 14.48 ± 2.37 years. In this group, 32% of the patients were hypodivergent (17 patients; 8 females, 9 males; mean age, 14.58 ± 2.26 years), 32% of the patients were normodivergent (17 patients; 8 females, 9 males; mean age, 14.64 ± 2.47 years), and 36% of the patients were hyperdivergent (19 patients; 10 females, 9 males; mean age, 14.24 ± 2.37 years).

When interactive effects were examined, no significant relationship was observed between all subgroups and chronological age ($p < 0.05$). When the relationship between craniofacial pattern and gender was evaluated, no significant relationship was found between face type and gender ($p > 0.05$). When we examined the effects of different craniofacial growth patterns on head posture, no statistically significant difference was found between different malocclusion and face-type groups in all head posture measurements ($p > 0.05$) (Table 2).

Table 1. Demographic statistics stratified by craniofacial growth pattern

	(Group 1) Class I			(Group 2) Class II			(Group 3) Class III			TOTAL			Class vs Face Type		
	Mean ± SD	n	P	Mean ± SD	n	P	Mean ± SD	n	P	Mean ± SD	n	P	Mean ± SD	n	P
Chronological Age															
Hypodivergent	14.61 ± 2.01	(n = 17)		14.39 ± 2.17	(n = 18)		14.58 ± 2.26	(n = 17)		14.52 ± 2.11	(n = 52)				
Normodivergent	14.36 ± 2.43	(n = 19)		14.43 ± 2.08	(n = 17)		14.64 ± 2.47	(n = 17)		14.47 ± 2.33	(n = 53)		NS		NS
Hyperdivergent	14.39 ± 2.43	(n = 19)		14.48 ± 2.31	(n = 20)		14.24 ± 2.37	(n = 19)		14.37 ± 2.35	(n = 58)				
TOTAL	14.45 ± 2.35	(n = 55)		14.43 ± 2.19	(n = 55)		14.48 ± 2.37	(n = 53)		14.45 ± 2.34	(n = 163)		NS		NS
GENDER *															
Hypodivergent	9 (52.94)			9 (50)			8 (47.06)			26 (50)					
	8 (47.06)			9 (50)			9 (52.94)			26 (50)					
Normodivergent	10 (52.63)			9 (52.94)			8 (47.06)			27 (50.95)					NS
	9 (47.37)			8 (47.06)			9 (52.94)			26 (49.05)					NS
Hyperdivergent	10 (52.63)			10 (50)			10 (52.63)			30 (51.73)					
	9 (47.37)			10 (50)			9 (47.37)			28 (48.27)					
TOTAL	29 (52.72)			28 (50.91)			26 (49.05)			83 (100)					NS
	26 (47.28)			27 (49.09)			27 (50.95)			80 (100)					

F=Female; M=Male Pt: Two-way ANOVA; P*: Pearson's chi-square test; NS: Not significant, p > 0.05

Table 2. Comparison of head posture measurements according to craniofacial growth pattern.

		Class I Mean ± SD	Class II Mean ± SD	Class III Mean ± SD	TOTAL Mean ± SD	Class p	Face Type p	Class x Face Type p
HEAD POSTURE MEASUREMENTS	SN-CVT	Hypodivergent	104.76±8.24	106.33±8.73	101.09±9.29	104.06±8.75		
		Normodivergent	105.5±8.57	108.9±7.41	104.28±9.71	105.89±8.56	NS	0.747
		Hyperdivergent	106.08±9.66	110.69±7.59	105.2±6.07	106.65±7.78		
		TOTAL	105.44±8.82	108.64±7.91	103.52±8.35	105.86±8.34	NS	
	SN-OPT	Hypodivergent	99.12±8.25	101.87±9.59	98.8±11.33	97.93±9.72		
		Normodivergent	102.47±9.17	102.16±8.17	98.16±9.08	100.19±8.81	NS	0.443
		Hyperdivergent	101.29±9.46	104.87±8.43	101.89±6.45	103.35±8.11		
		TOTAL	99.97±8.96	102.96±8.74	98.58±8.96	99.54±8.87	NS	
	FH-CVT	Hypodivergent	96.14±8.04	98.34±8.27	94.16±8.06	95.21±8.11		
		Normodivergent	98.53±8.58	99.25±7.26	96.84±8.57	96.87±8.13	NS	0.683
		Hyperdivergent	98.61±8.61	101.39±7.88	94.1±6.31	97.36±7.61		
		TOTAL	96.76±8.41	98.66±7.81	94.03±7.64	96.48±7.96	NS	
	FH-OPT	Hypodivergent	91.7±7.57	94.83±8.81	90.21±8.97	90.91±8.45		
		Normodivergent	93.25±9.14	94.7±7.93	92.69±8.79	92.57±8.62	NS	0.552
		Hyperdivergent	94.51±8.63	96.7±8.17	91.7±6.77	93.4±7.85		
		TOTAL	91.82±8.44	94.87±8.31	90.53±8.18	92.39±8.31	NS	
CVT-OPT	Hypodivergent	5.48±2.74	4.76±2.73	5.14±2.91	5.12±2.79			
	Normodivergent	5.26±3.02	4.86±3.04	4.21±2.56	4.77±2.87	NS	0.645	
	Hyperdivergent	5.16±3.79	5.21±3.42	3.75±2.78	4.71±3.33			
	TOTAL	5.29±3.18	4.94±3.06	4.36±2.75	4.86±2.98	NS		

P: Two-way ANOVA; NS: not-significant p>0.05

DISCUSSION

When performing orthodontic diagnosis and planning the corresponding treatment, the head posture must be considered on account of its effects on the development of the tooth–jaw–face system and its relations with this system. Head posture may be an effective factor in ensuring and maintaining harmony between the jaws, which is one of the main goals of orthodontic treatment. During the selection of participants in our study, we sought to minimize factors that may affect the natural head position beyond the limits of change compared with normal individuals and cause positional changes in these structures.²²

Orthodontic, orthognathic, and functional treatments have been reported to be able to change the head

posture. Structural and positional changes created by treatment of the chewing system, especially of the mandible and tongue, can change the head posture; thus, changes that may occur in functions such as chewing, swallowing, and breathing as a result of treatment can directly affect these structures.^{18,22} Given these findings, individuals with a history of previous orthodontic, orthopedic, or orthognathic treatment were not included in our study.

Attention must be paid to head posture not only in posture-related studies but also in routine cephalometric radiographs. Compared with other positions, taking radiographs in the natural head position during the cephalometric evaluation of teeth, jaws, head, and face is better able to reflect the true characteristics of the patient.²³ Lateral cephalometric films are frequently

used in orthodontic practice to evaluate individual growth patterns and skeletal, dental, and soft tissue morphologies to diagnose skeletal anomalies, plan treatment, predict future changes, and examine head and facial parameters in individuals or communities. The greatest benefit of cephalometry compared with other techniques is that it is a quantitative method that enables the evaluation and analysis of the relationship between skeletal and dental structures and soft tissue. While cephalometric films do not show three-dimensional details, they offer higher image resolution than any other imaging method, including computed tomography. In the present study, we used cephalometry as a research material because cephalometric films are the most widely used imaging tools in orthodontic studies.

In our study, no statistically significant difference in head posture measurements was observed among the skeletal Class I, Class II, and Class III groups and different face types. Cole and Ertürk divided patients into Class I, Class II, and Class III according to ANB angle and examined differences in head posture among these groups.^{23,24} The team observed that SN/CVT measurements determining the craniocervical posture are statistically different between the skeletal Class II and Class III groups and between the skeletal Class I and Class II groups.²⁴

Ertürk et al. argued that SN/CVT measurements do not differ significantly between skeletal Class I, Class II, and Class III groups.²³ The researchers further determined that the head is positioned downward in the Class III group and upward in the Class II group compared with that in the Class I group^{23,24}. In our study, no significant difference in SN/CVT measurements was found between the skeletal Class I, Class II, and Class III groups. Therefore, head posture did not show a statistically significant difference among these groups. However, we also observed that the head was positioned lower in the Class III group and higher in the Class II group compared with that in the Class I group. Thus, our findings are similar to the findings of Ertürk et al. but differ from those of Cole. The difference between Cole's findings and our results may be attributed to differences in the ANB angles used for grouping, as well as differences in the age, sex, and growth-development periods of the groups.

Soytarhan and Aras examined head position in different malocclusions and observed that although the head was not at a significant level in the Class III group.²⁵ In this respect, the findings of Soytarhan and Aras are similar to those of our study. Hedeyati et al. investigated the characteristics of cranial base inclination and craniocervical posture in adults with skeletal Class I, Class II, and Class III malocclusions and found no significant difference in craniocervical posture and cervical colon curvature among the groups.²⁶ In a study of children aged 11–14 years, Liu

et al. did not observe a significant difference among groups in terms of craniocervical posture and cervical colon curvature.¹¹ Our findings on head posture, craniocervical posture, and cervical colon curvature are in line with those of Liu et al.

The unique feature of our study is that, besides different malocclusions, we also examined different facial types. However, because previous studies examining nine subgroups are not available in the literature, exact comparisons of our findings with earlier results cannot be conducted. Thus, comparisons with studies presenting similar findings were made. The current study can help guide future research on the factors affecting head posture and contributes to the literature by examining head posture with a large sample size using different methods.

CONCLUSION

Among the groups studied, craniocervical angle measurements are lowest in Class III and hypodivergent individuals. Head posture is similar among subgroups of different malocclusion types separated by vertical growth pattern.

CONFLICT OF INTEREST

All authors declare no conflict of interest related to the publication of this research.

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(Received April 26, 2020; Accepted November 1, 2020)