Relationship between head posture and anterior-posterior skeletal patterns in a group of female patients

Laila F. Baidas, MSC, FDS.

ABSTRACT

الأهداف: تقييم العلاقة بين وضعية الرأس والأنماط المختلفة من الهيكل العظمي على مجموعة من المرضى الإناث البالغين.

الطريقة: أجريت هذه الدراسة على 75 من الأشعة الجانبية السيفالومترية لمريضات تقويم الأسنان من عمر من 25–18 عام خلال الفترة من مايو 2012م إلى يناير 2013م. قسمت الأشعة الجانبية السيفالومترية اعتماداً على زاوية (ANB) إلى 3مجموعات هيكلية من الدرجة الأولى والثانية والثالثة. وقد تم تحديد واستخدام 23 متغير هيكلي وشكلي و تمت معالجة البيانات إحصائياً باستخدام اختبارات كرسل والس و مان ويتني و بيرسون.

النتائج: أظهرت وجود فروق ذات دلالة إحصائية في ميلان الفك السفلي بين المجموعة الأول والثانية (P >0.04) ، وبين المجموعة الثانية والثالثة (P>0.028). وكما تمت ملاحظة فروق ذات دلالة إحصائية في انحناء الفقرات العنقية بين المجموعة الأولى والثانية، وبين المجموعة الأولى والثالثة (P>0.000) . لوحظ وجود علاقة إيجابية بين الزاوية العنقية والعمود العنقي العلوي والوسطى في المجموعات الأولى والثانية و الثالثة. وبينما لوحظ علاقة عكسية بين الانحناء العنقي مع الجزء العلوي من العمود الرقبي في المجموعة الأولى، وعلاقة إيجابية في المجموعتين الثانية والثالثة. وكما لوحظ ارتباط كبير بين الزاوية العنقية ووضعية العنق في المجموعة الثالثة والذي نتج عنه وضعية الرأس إلى الأمام مع استقامة أسفل العمود العنقي. لوحظ ايضاً وجود علاقة سلبية بين الزاوية العنقية ووضعية العنق في المجموعة الثانية التي تدل على وضعية الرأس إلى الخلف.

خاتمة: لا توجد علاقة واضحة بين وضعية الرأس والأنماط الهيكلية المختلفة، كما أنه لا يبدو أنها ذات تأثير على نمو الأنماط الهيكلية.

Objectives: To evaluate the relationship between head posture and anteroposterior skeletal patterns in female adult patients.

Methods: The study included 75 lateral cephalograms of orthodontic patients in the age range of 18-25 years. The study was conducted from May 2012 to January 2013 at the College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia. The lateral cephalograms were divided into 3 groups based on the anterior-posterior skeletal relationship angle: skeletal class I, II, and III. Twenty-three craniofacial morphological variables were identified and used. The Kruskal-Wallis and Mann-Whitney U tests were used to determine significant differences among the 3 skeletal classifications. The Spearman correlation coefficient between the cervical lordosis angle and the cervical curvature with the postural variables were estimated. Significance was set at the $p<0.05$ level.

Results: Significant differences were observed in the mandibular plane inclination between class I and II ($p<0.04$), and between class II and III ($p<0.028$). Cervical curvature showed a significance difference between class I and II, and between class I and III ($p<0.000$). In Class I, II, and III the cervical lordosis angle positively correlated with the upper and middle parts of the cervical column. Cervical curvature correlated negatively with the upper part of the cervical column in class I, while positively correlated in class II and III. The class III group showed a more forward head posture, while the class II group showed a greater head extension.

Conclusion: No clear relationship was found between head posture and the different skeletal patterns, and it does not seem to play a significant role in the development of different anteroposterior skeletal relationships.

Saudi Med J 2014; Vol. 35 (1): 72-80

From the Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia.

Received 25th June 2013. Accepted 18th november 2013.

Address correspondence and reprint request to: Dr. Laila F. Baidas, Consultant and Assistant Professor, Department of Pediatric Dentistry and Orthodontics, College of Dentistry, PO Box 5967, King Saud University, Riyadh 11432, Kingdom of Saudi Arabia. Tel. +966 (11) 4641791. Fax.+966 (11) 4190883. E-mail: lbaidas@ksu.edu.sa / lailabaidas2003@yahoo.com

Normal craniofacial development depends on many factors. Understanding the coordinated mechanism that contributes to normal development is important in the diagnosis and treatment planning process. The cervical vertebrae are part of the craniocervical mandibular system. This system is made up of 3 main structures: temporomandibular joint (TMJ), occipital atlas axis articulation, and hyoid bone with its suspensor system. These structures work together with the vertebral column via muscles and ligaments.[1] Consequently, head posture in relation to the cervical column has been found to be associated with craniofacial morphology in previous studies.[2-7] These studies concluded that subjects with extended head posture (reduced cervical lordosis angle) had an increased lower anterior facial height, reduced sagittal jaw discrepancy, and a steeper inclination of the mandible. However, when the head was flexed in relation to the cervical column (increasing the cervical lordosis angle), a shorter anterior facial height, larger sagittal jaw discrepancy, and a less steep inclination of the mandible were found. Head posture is linked to the development and function of dentofacial structures, as with extended head, a reduced forward rotation of the mandible was observed.[8] Cervical posture was linked to mandibular length, with longer mandibles associated with cervical columns more inclined to a true horizontal.[9] Mandibular length was also positively correlated with straightness of the cervical column (reduced cervical lordosis angle).[10]

Solow and Tallgren[11] observed that this relationship of head posture to the cervical column had a positive correlation with vertical jaw relationship and craniocervical angulation, but a lack of association with anteroposterior jaw relationships. Most studies on the relationship between craniocervical posture and craniofacial morphology have concentrated on the relationship between the head posture and vertical jaw relationship, and the divergence and inclination of the mandibular and maxillary bases, rather than on the anteroposterior jaw relationship. D'Attilio et al[12] conducted a study on children (average age: 9.5 years) to find the relationship of cervical posture and different antero-posterior skeletal relationships. They found that children with skeletal class III had a straight cervical column at the lower segment, while those with skeletal class II had head extension in the middle segment of the spinal column.[12] Another study found that subjects with class II malocclusion had poor neck posture and increased anterior facial height.[10] Bench[13] concluded that patients with dolichocephalic faces often had a tendency for the spinal column to be straight and long, whereas brachycephalic subjects appeared to have a curved spinal column. Hellsing et al[14] reported that the inclination of the middle segment of the spinal column correlated with mandibular and maxillary prognathism, but the inclination of the upper segment of the cervical column was negatively correlated with anterior facial height.[6,14] Arntsen and Sonnesen[15] found that the deviations of cervical vertebral column morphology in class II malocclusion were significantly associated with extension of the head in relation to the cervical vertebral column.[15] This is also associated with a large sagittal jaw relationship, a large inclination of the jaws, and a large cranial base angle.

Since the relationship of head posture and different antero-posterior skeletal relationships had been found in children,[12] and in order to clarify this relationship in adults, this study was carried out on a group of female adult patients, without considering gender differences. Therefore, the purpose of this study was to investigate the relationship between head posture and anterior posterior jaw relationship. The importance of this study stems from attempting to better understand the relationship between the postural and morphological variables of patients.

Methods. Pre-treatment lateral cephalograms were collected from the records of 75 orthodontic patients, aged 18-25 years (mean age: 20.96 ± 2.51 years). Only female Saudi subjects were included in this study. The selection was based on the anterior-posterior skeletal relationship (ANB angle) and normal vertical skeletal relationship. Patients who had previous orthodontic treatment, loss of teeth (except for congenitally missing teeth and third molars), nasal obstruction, and TMJ pain were excluded. Sample size was established by MINITAB, Release 14 (MINITAB Inc., State College, PA, USA), software, based on the power of 0.88, which indicated that a sample size of 25 subjects in each group was adequate and would allow detection of any clinically significant difference between the 3 groups (at a significance level of α=0.05). This study was approved by the Ethics Committee of the Research Center of the Faculty of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia. The study was conducted from May 2012 to January 2013, and carried out at the College of Dentistry, King Saud University.

Disclosure. This study was supported by the Research Center, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia.

Lateral profile radiographs were taken with teeth in occlusion and standardized head posture, as described by Solow and Tallgren.[2] The lateral radiographs were exposed in the natural head position (mirror position) with the subjects standing in orthoposition, which is the intention position from standing to walking.[3] This was carried out in the College of Dentistry, King Saud University, using the PM 2002 CC Proline Cephalixcephalostat (Planmeca, Helsinki, Finland). Exposure data was 60-80 k and 14-12 mA, with an exposure time of 0.2-5 sec. Magnification factor was 1.1, with fixed film to focus plane distance of 165 cm, using a 18 x 24 cm cassette film with the rare earth screen. The true vertical was indicated on the films with a 0.5-mm weighted wire mounted on the head holder to represent the true vertical of the patient as described by Solow and Tallgren[16] (**Figure 1**).

The subjects were divided into 3 groups according to the anterior-posterior skeletal relationship (ANB) angle: ANB angle between one to 5 degrees (skeletal class I), larger than 5 degrees (skeletal class II), less than one degrees (skeletal class III). Fourteen reference points (10 points in the craniofacial area and 4 in the cervical region were marked and traced for each radiograph[2] (**Table 1 and Figure 1**). The bodies of the cervical vertebrae (C2, C4, and C6) were identified, and the most inferoposterior point of each body, and the more posterior point of the odontoid process were marked.[17] Ten reference lines were used (**Table 1, Figure 2**). Three lines were identified (cervical vertebrae tangent [CVT], lower part of cervical spine [EVT], and odontoid process tangent [OPT]) to represent the upper, middle, and lower parts of the cervical posture. In order to determine if a relationship exists between head posture and anterior-posterior skeletal pattern, 23 craniofacial morphological variables were termed: the sagittal intermaxillary relation, vertical relation, cervical posture, craniofacial posture, and craniocervical posture (**Table 2**).[12,17,18]

The reliability of the measurements was determined by statistically analyzing the difference between double measurements taken with an interval of at least one week after initial measurements for 15 selected cephalograms. The measurement error was calculated according to the following equation (Dahlberg's formula): $X^2 = (\sum D^2/2N)$, where D is the difference between duplicate measurements, and N is the number of double measurements.[19] No significant differences were found between the 2 measurements. The reliability measurement showed that the intra-observer error variance for all variables was less than 5% of the whole sample, with the method error ranging from 0.15-3.44%.

Data was statistically analyzed using the Statistical Package for Social Science version 16 (SPSS Inc., Chicago, IL, USA). The normality test was applied to the data using Shapiro-Wilks and Levine's variance homogeneity test. The data were found to be not normally distributed. Nonparametric tests outcomes were used and expressed as median, 25th, and 75th percentiles, and range. The Kruskal-Wallis test for nonparametric medians was used to determine significant differences if any among the 3 independent groups, and the Mann-Whitney U test was applied for pairwise comparisons

Figure 1 - The true vertical of the patient as described by Solow and Tallgren.[16] Reference points: S - sella; N - nasion; A point - deepest point at the anterior wall of maxilla; B point - deepest point at the anterior wall of mandible; ANS - anterior nasal spine; PNS - posterior nasal spine; Me - menton; Go - Gonion; Gtp - posterior tangent point of mandibular line; Ar - articulare; Cv2tg - tangent point on odontoid process; Cv2ip - the most postero-inferior point on 2nd cervical vertebrae; Cv4ip - the most postero-inferior point on 4th cervical vertebrae; Cv6ip - the most postero-inferior point on 6th cervical vertebrae.

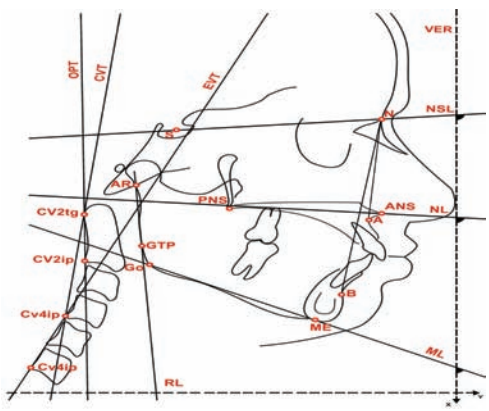

Figure 2 - The reference lines used. Reference points: Ver - true vertical; NSL - cranial line; NL - nasal line; ML - mandibular line; RL - ramus line; NA - line extended between N and A, NB - line extended between N and B; OPT - odontoid process; CVT - cervical vertebrae tangent; EVT - lower part of the cervical spine.

Table 1 - Reference points and reference lines used in the craniofacial area and in the cervical region of the studied orthodontic patients.

References	Description
Reference points	
S	Sella - the center of the sella turcica.
N	Nasion - the most anterior point on the frontonasal suture
A	A point - the most deepest point at the anterior wall of maxilla
B	B point - the most deepest point at the anterior wall of mandible
ANS	Anterior nasal spine - the apex of the anterior nasal spine
PNS	Posterior nasal spine - tip of the posterior spine of the palatine bone in the hard palate
Me	Menton point - the most inferior point of chin
Go	Gonion point - the most posterior and inferior point of the mandible
GtP	Posterior tangent at the angle of the mandible - the point of contact of the tangent to the angle of the point mandible that passes through articulare
Ar	Articulare point - the intersection point between external of cranial base and the dorsal contour of the condylar head or neck
Cv2tg	The tangent point of OPT on the odontoid process of the second cervical vertebra
Cv2ip	The most postero-inferior point on the corpus of the second cervical vertebra
Cv4ip	The most posterior-inferior point on the corpus of the fourth cervical vertebra
Cv6ip	The most inferior-posterior point on the corpus of the sixth cervical vertebra
Reference lines	
Ver	True vertical line - the vertical line projected on the film
NSL	Nasion-sella line - the line through N and S
NL	Nasal line - the line through SP and PM
ML	Mandibular line - the line through Me and Gn
RL	Ramus line - the line extending between Ar and GtP
NA	The line extending between nasion and point A
NB	The line extending between nasion and point B
OPT	Odontoid process tangent (the upper part of cervical vertebrae) - the posterior tangent to the odontoid process through Cv2ip
CVT	Cervical vertebrae tangent (the middle part of cervical vertebrae) - the posterior tangent to the odontoid process through Cv4ip
EVT	The lower part of cervical spine - line through Cv4ip and Cv6ip

of the groups. The Spearman correlation coefficient between the cervical lordosis angle (CVT/EVT), and cervical curvature (CVT/OPT) with the other postural variables among the 3 classifications were estimated. Significance for all statistical tests was set at the $p<0.05$ level.

Results. Descriptive statistics for postural variables are presented in **Table 3**. Median, 25th and 75th percentiles, and range of cervical posture, craniofacial posture, and craniocervical posture are all displayed. Kruskal-Wallis test for 3 independent skeletal classifications (class I, class II, and class III) is shown in **Table 3**. Mandibular line inclination (ML)/true vertical (Ver) ($p<0.04$), and cervical curvature CVT/OPT ($p<0.00$) showed a significant difference between the 3 skeletal classifications. **Table 4** shows the difference between the medians of postural variables of 2 skeletal classifications. Significant differences were observed in the mandibular line inclination (ML/Ver) between class I and class II ($p<0.04$), and between class II and class III ($p<0.028$). Cervical curvature (CVT/OPT), which is the angle formed between the upper and middle sections of the spinal column, showed a significant difference between class I and class II, and between class I and class III ($p<0.000$ for both). No significant differences were observed among the 3 skeletal class groups in cervical lordosis angle (CVT/EVT), which is the angle formed between the middle and lower sections of the spinal column. No significant difference was found among the class I, II, and III values at the inclination of upper (OPT/Ver), middle (CVT/Ver), and lower (EVT/Ver) segments to the spinal column. No significant differences were found among the 3 classifications in respect to the cranial base, maxillary base, mandibular base, and ramus line with the upper and middle sections of the spinal column (nasion-sella line [NSL]/OPT, NSL/CVT, nasal line [NL]/OPT, NL/CVT, mandibular line [ML]/OPT, ML/CVT).

The results of the Spearman correlation coefficient between the cervical lordosis angle (CVT/EVT) and postural variables (cervical posture, cranial posture, and

Table 2 - Description of the measurements of craniofacial morphological variables used in the studied orthodontic patients.

Numbers	Measurements	Description	Meaning
Sagittal relation			
1	SNA	Sella-nasion-point A (SNA) angle	Anteroposterior position of the maxilla relative to the cranial base
2	SNB	Sella-nasion-point B (SNB) angle	Anteroposterior position of the mandible relative to the cranial base
3	ANB	Point A-nasion-point B (ANB) angle	Difference between angles SNA and SNB
Vertical relation			
4	NL-ML	Angle between nasal line (NL) line and mandibular line (ML) line	Maxillary plane inclination to mandibular plane
5	NSL-NL	Angle between nasion-sella line (NSL) and NL line	Cranial plane inclination to maxillary plane
6	NSL-ML	Angle between NSL line and ML line	Cranial plane inclination to mandibular plane
Cervical posture			
7	OPT/Ver	Downward opening angle between odontoid process tangent (OPT) line and true vertical line (Ver) line*	Odontoid angle (upper cervical column posture)
8	CVT/Ver	Downward opening angle between cervical vertebrae tangent (CVT) line and Ver line*	Middle cervical column posture
9	EVT/Ver	Downward opening angle between lower part of cervical spine (EVT) line and Ver line*	Lower cervical column posture
Craniofacial posture			
10	NSL/Ver	Downward opening angle between nasion-sella line (NSL) line and Ver line*	Anterior cranial base inclination
11	NL/Ver	Downward opening angle between NL line and Ver line*	NL inclination
12	ML/Ver	Downward opening angle between ML line and Ver line*	ML inclination
13	RL/Ver	Downward opening angle between ramus line (RL) line and Ver line*	RL inclination
Craniocervical angulation			
14	CVT/EVT	Downward opening angle between the cervical vertebrae tangent (CVT) line and EVT line	Cervical lordosis angle (The angle formed between the middle and lower part and the cervical column)
15	CVT/OPT	Downward opening angle between CVT line and odontoid process tangent (OPT) line*	Cervical curvatures (The angle formed between the upper and middle part and the cervical column)
16	NSL/OPT	Downward opening angle between NSL line and OPT line*	Cranial base inclination upon cervical column
17	NSL/CVT	Downward opening angle between NSL line and CVT line*	
18	NL/OPT	Downward opening angle between NL line and OPT line*	Nasal base inclination upon cervical column
19	NL/CVT	Downward opening angle between NL line and CVT line*	
20	ML/OPT	Downward opening angle between ML line and OPT line*	Mandibular base inclination upon cervical column
21	ML/CVT	Downward opening angle between ML line and CVT line*	
22	RL/OPT	Downward opening angle between RL line and OPT line*	Mandibular ramus inclination upon cervical column
23	RL/CVT	Downward opening angle between RL line and CVT line*	

*The standard used for angles related to the true vertical line was that the downward opening angles formed behind the vertical were considered negative, whereas angles formed in front were considered positive[12]

Table 3 - Descriptive statistics for postural variables (25 percentile [p.le], median, 75 p.le, and range) in 3 skeletal classifications (class I, class II, and class III).

Variables	Class I (no. 25)				Class II (no. 25)				Class III (no. 25)				*P*-value*
	25 p.le	Median	75 p.le	Range	25 p.le	Median	75 p.le	Range	25 p.le	Median	75 p.le	Range	Cl I/Cl II/ Cl III
CVT/EVT	-0.5	5	10	26	+1	5	12	30	-2.5	1	10	31	0.71
OPT/Ver	-6.0	-3	3.5	26	-8.5	-4	0.5	37	-7.5	-1	7	30	0.3
CVT/Ver	-10.5	-7	-4.5	21	-10	-6	-3.5	33	-10	-6	-3	25	0.1
EVT/Ver	-15.0	-11	-7.5	30	-16	-10	-7	26	-19	-10	-5.5	25	0.91
NSL/Ver	91.5	95	100	26	94	97	99.5	25	92.5	97	100	16	0.66
NL/Ver	84.5	88	91.5	20	84	90	93	18	85	89	95.5	22	0.65
ML/Ver	57.0	60	67	35	54.5	57	60.5	24	57	60	70	43	(0.04)*
RL/Ver	2.5	7	14	22	3.5	8	12.5	35	6.5	10	14.5	20	0.15
CVT/OPT	-8.0	-5	-3	11	2.5	5	6	8	2.5	5	7	12	(0.000)†
NSL/OPT	92.0	97	106.5	33	94	101	105	35	90.5	98	104	31	0.60
NSL/CVT	99.0	103	107	32	97	102	108	41	96.5	104	106.5	32	0.99
NL/OPT	85.5	91	98.5	30	85	90	96	30	84	9	95	37	0.97
NL/CVT	91.5	96	100.5	28	87.5	95	100	27	90.5	95	100	34	0.97
ML/OPT	56.5	64	71	55	57	63	68	29	57.5	63	68.5	28	0.81
ML/CVT	63.0	70	75	54	60	64	70	30	62	68	73	32	0.20
RL/OPT	5.0	10	15	32	6.5	11	18	34	6	14	19.5	29	0.40
RL/CVT	7.5	15	18	31	8.5	17	20.5	31	13	18	22	28	0.234

CVT - cervical vertebrae tangent, EVT - lower part of cervical spine, OPT - odontoid process tangent, Ver - true vertical line, NSL - nasion-sella line, NL - nasal line, ML - mandibular line, RL - ramus line, *Kruskal-Wallis test, significance at *p<0.05, †p<0.001

Table 4 - Mann-Whitney U test between 2 independent skeletal classifications.

Variables	*P*-value		
	Cl I /Cl II	Cl II/Cl III	Cl I/Cl III
CVT/EVT	0.89	0.573	0.409
OPT/Ver	0.17	0.189	0.938
CVT/Ver	0.77	0.899	0.755
EVT/Ver	0.94	0.792	0.633
NSL/Ver	0.41	0.930	0.376
NL/Ver	0.63	0.593	0.382
ML/Ver	(0.04)*	(0.028)*	0.599
RL/Ver	0.67	0.142	(0.071)
CVT/OPT	(0.000)†	0.637	(0.000)†
NSL/OPT	0.37	0.403	0.946
NSL/CVT	0.969	0.884	0.984
NL/OPT	0.77	0.961	0.823
NL/CVT	0.876	0.793	0.861
ML/OPT	0.541	0.640	0.808
ML/CVT	0.107	0.156	0.719
RL/OPT	0.478	0.566	0.170
RL/CVT	0.37	0.361	0.103

Significance at *p<0.05, †p<0.001. CVT - cervical vertebrae tangent, EVT - lower part of cervical spine, OPT - odontoid process tangent, Ver - true vertical line, NSL - nasion-sella line, NL - nasal line, ML - mandibular line, RL - ramus line

Table 5 - Spearman correlation coefficient between cervical lordosis angle (CVT/EVT), and postural variables among the 3 skeletal classification (class I, class II, and class III) (N=75).

Variables	Correlation within class I (n=25)		Correlation within class II (n=25)		Correlation within class III (n=25)	
		P-value		*P*-value		*P*-value
OPT/Ver	0.54	(0.005)†	0.614	(0.001)†	0.590	(0.002)*
CVT/Ver	0.543	(0.005)†	0.507	(0.010)*	0.540	(0.005)†
EVT/Ver	-0.699	(0.000)‡			-0.499	(0.01)*
NSL/Ver	0.432	(0.031)*				
NL/Ver			0.428	(0.033)*		
RL/Ver			0.461	(0.020)*		
NSL/OPT					-0.466	(0.019)*
NL/OPT					-.421	(0.036)*
ML/OPT			-0.435	(0.030)*		
ML/CVT			-0.495	(0.012)*		
RL/OPT					-0.560	(0.004)†
RL/CVT					-0.525	(0.007)†

Significant correlation at *p<0.05, †p<0.01, ‡p<0.001. Non-significant correlations have been removed. CVT - cervical vertebrae tangent, EVT - lower part of cervical spine, OPT - odontoid process tangent, Ver - true vertical line, NSL - nasion-sella line, NL - nasal line, ML - mandibular line, RL - ramus line

Table 6 - Spearman correlation coefficient between cervical curvature (CVT/OPT) and postural variables among the 3 skeletal classifications (class I, class II, and class III) (N=75).

Variables	Correlation within class I (n=25)		Correlation within class II (n=25)		Correlation within class III (n=25)	
		P-value		*P*-value		*P*-value
OPT/Ver	-0.620	(0.001)†	0.578	(0.002)†	0.508	(0.009)†
CVT/Ver			0.416	(0.039)*		
EVT/Ver					-0.456	(0.022)*
NSL/Ver					0.439	(0.028)*
ML/Ver					0.427	(0.033)*
RL/Ver					0.397	(0.049)*
NSL/OPT	0.457	(0.022)*	-0.402	(0.046)*		
NL/OPT	0.412	(0.041)*	-0.599	(0.002)†		
NL/CVT			-0.431	(0.031)*		
ML/OPT			-0.558	(0.004)*		

Significant correlation at *p<0.05, †p<0.01. Non-significant correlations have been removed. CVT - cervical vertebrae tangent, EVT - lower part of cervical spine , OPT - odontoid process tangent, Ver - true vertical line, NSL - nasion-sella line, NL - nasal line, ML - mandibular line, RL - ramus line

craniocervical posture) are presented in **Table 5**. In class I subjects, a large cervical lordosis angle is positively correlated with the inclination of the upper cervical column (OPT/Ver, p<0.005), and inclination of the middle cervical column (CVT/Ver, p<0.005), while it is negatively correlated with the inclination of the lower cervical column (EVT/Ver; p<0.000). A significant correlation was observed between the cervical lordosis angle and the anterior cranial base inclination (p<0.031). In class II subjects, the cervical lordosis angle is positively correlated with the inclination of the upper and middle cervical column (OPT/Ver, CVT/Ver, p<0.001, and p<0.01). A significant correlation was observed between the cervical lordosis angle, and the maxillary line, and ramus line inclinations, while it is negatively correlated with the mandibular plane inclination upon the cervical column. In class III subjects, the cervical lordosis angle is positively correlated with upper cervical column posture (OPT/Ver, p<0.02) and middle cervical column posture (CVT/Ver, p<0.005), while it is negatively correlated with lower cervical column posture (EVT/Ver, p<0.01). The craniocervical angulation (RL/OPT, RL/CVT, NSL/OPT, and NL/OPT) was negatively correlated with cervical lordosis.

Table 6 demonstrates the results of the Spearman correlation coefficient between cervical curvature (CVT/OPT) and postural variables (cervical posture, cranial posture, and craniocervical posture). In the class I group, cervical curvature is negatively correlated with the inclination of the upper part of the cervical column (OPT/Ver, p<0.001), and positively correlated with cranial base inclination and nasal base inclination (NSL/OPT, NL/OPT, p<0.02, p<0.4). In class II, the cervical curvature is positively correlated with the posture of the upper and middle parts of the cervical column (OPT/Ver, p<0.002 and CVT/Ver; p<0.04). In class III, the cervical curvature is positively correlated with inclination of the upper cervical column (OPT/Ver, p<0.01), and negatively correlated with inclination of the lower part of the cervical column (EVT/Ver, p<0.022). When observing the class III skeletal classification group, cervical curvature was correlated with the craniofacial posture (NSL/Ver, ML/Ver, RL/Ver). However, in the class II skeletal classification group, the craniocervical angulation (NSL/OPT, NL/OPT, NL/OPT, ML/OPT) was negatively correlated with cervical curvature.

Discussion. Previous investigations reported associations between head posture and craniofacial structure.[2-7] However, few studies have demonstrated the association between head posture and anteroposterior skeletal patterns.[10,12,18] In the present study, the relationship between head posture, and the anteroposterior skeletal relationship was investigated.

The present study was limited to female subjects only to remove the possible confounding factor of gender. Grave[20] reported that vertebral dimensions were larger in males than in females, and the gender difference was considerably more marked in Caucasians (20%) compared with Aborigines (10%) in Australia. The difference was explained by a relatively lower homogeneity of the Caucasian group. Previous studies[21-23] found that cervical column inclination has also been linked to gender, as men usually exhibit a straightened cervical column, and women usually exhibit a partly reversed curvature. Some previous studies also included only female subjects.[18,23]

The present investigation showed that there were no significant differences in cervical lordosis angle among the 3 skeletal classifications. A previous study in children by D'Attilio et al[12] found a significant positive correlation between CVT/EVT angle and skeletal class III subjects, and it is associated with the significant straightening of the lower part of the cervical column (EVT/Ver) in subjects in skeletal class III. In the present study, no significant difference among the 3 groups was observed in the inclination of upper (OPT/Ver), middle (CVT/Ver), and lower (EVT/Ver) parts of the cervical column. This finding was in disagreement with earlier research. [10,12] Hellsing found that cervical lordosis decreased with increasing age.[6] The present study was comprised of adult subjects aged between 18 and 25

years, this might explain our result of no significant difference among different anterior-posterior skeletal relationships.

An interesting finding of the present study was that the mandibular line inclination to vertical plane (ML/Ver) among the 3 skeletal classifications was highly significant. The mandibular inclination in skeletal Class II classification was decreased compared to class I and class III ($p<0.04$, $p<0.028$). Our results disagree with those of D'Attilio et al,[12] who showed no difference in mandibular inclination among the 3 skeletal classifications in children.[12] However, the sample in this study was only comprised of subjects with a normal value of mandibular inclination (SN/GOGn). So we cannot take the difference in mandibular inclination among the 3 skeletal classifications into consideration, and the differences are minimal.

Our results found that the cervical lordosis angle (CVT/EVT) was positively correlated with inclination of the upper and middle parts of the cervical column (OPT/Ver, CVT/Ver), while negatively correlated with inclination of the lower part of the cervical column (EVT/Ver) in class I and class III skeletal patterns, but more obviously with the class I skeletal pattern, and it was in agreement with D'Attilio et al.[18] The class III skeletal group showed a significant correlation between the decreased cervical lordosis angle and the inclination of the ramus plane to the upper and middle parts of the cervical column. This revealed that the straightened lordotic curve of the spine seems to be related to forward head posture in skeletal class III subjects. This is in agreement with previous study.[12] The skeletal class II group showed a significant correlation between increased cervical lordosis angle and decreased mandibular inclination to the upper and middle parts of the cervical column. Hellsing[6] showed an association between an increase in the cervical lordosis angle and a decrease in inclination of the mandible, which our findings are in agreement with. Other studies of adult females with skeletal class II, found a significantly negative correlation between the cervical lordosis angle (CVT/EVT) and mandible inclination, the more divergent the mandible, the lower the cervical lordosis angle.[10,18] A probable explanation is that the position of the mandible in skeletal class II, seems to close the mandible in a posterior position, possibly creating compression at the retromandibular area and decreasing the cervical lordosis angle. Huggare and Raustia[24] claimed an increase in craniocervical angulation had no statistically significant increase in cervical lordosis in patients with craniomandibular dysfunction.

The most significant finding in this study was that the cervical curvature (CVT/OPT) angle was significantly increased in class II and class III subjects compared to class I subjects, but it does not have a significant effect on craniocervical angulation variables among different skeletal patterns. Further findings of the study are concerned with the correlation of the cervical curvature with craniocervical variables. A significant correlation between cervical curvature and inclination of the upper part of the cervical column was evident in class I, II, and III skeletal classifications. When comparing class III subjects with class II and class I, the craniofacial angles (NSL/Ver, NL/Ver, ML/OPT) showed a significant correlation with cervical posture, which suggested a more forward head posture present with a straighter curve of the lower cervical column (EVT/Ver). However, in the class II skeletal pattern, cervical curvature negatively correlated with cranial base, maxillary base, and mandibular base inclination upon the upper part of the cervical column. This dissimilarity between class II and III indicated a greater head extension in class II subjects. These results coincided with other studies.[10,12] The study carried out by Sonnesen,[25] showed that the cranial base could be the developing link between the cervical vertebral column and the jaws, so the cranial base can influence craniofacial morphology. A large cranial base inclination in adults is associated with retrognathia and inclination of the jaws. Springate[26] reported no causal relationship between the initial posture and the abnormality in facial growth; however, the change in posture is strongly linked to the direction of facial growth and subsequent development of facial morphology. AlKofide and AlNmankani[27] conducted a study of the relationship between certain malocclusal traits and head posture and found a positive correlation between crowding in the upper arch and increase in cervical curvature. They reported that class II malocclusion showed a highly significant relationship with craniovertical angles (NSL/Ver, NL/Ver).

The important aspect of the study is that any deviations in head posture may prove useful when considering diagnosis and evaluating the etiological factors, especially in patients with severe skeletal malocclusions. The primary limitation of this investigation was that the measurements were based on 2-dimensional cephalometric radiographs, and only adult female patients were included in the study. A longitudinal study is required to better understand the relation between head posture and craniofacial morphology. Further 3D studies are needed to give more accurate quantitative analysis.

Within the limitations of this study, the following conclusion can be made: there were no clear differences between head posture and the different skeletal patterns. The cervical curvature angle was increased in class I and class III subjects. Class II subjects had a significantly smaller mandibular inclination compared with class I and class III subjects. The cervical lordosis angle was positively correlated with inclination of the upper and middle parts of the cervical column in all skeletal patterns, while negatively correlated with inclination of the lower part of the cervical column in the class I and class III skeletal patterns, which indicated a straighter lower part of the cervical column. It is proposed that class III subjects have a more forward head posture with a straighter curve of the lower cervical column; however, class II skeletal pattern subjects had a greater head extension.

Acknowledgment. *The authors sincerely thank Mr. Nasr Al-Maflehi for his assistance during the statistical analysis, and Dr. Asma AlEkrish for her assistance in revising the radiograph interpretations.*

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