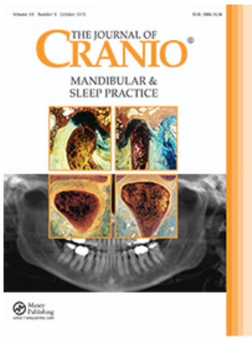

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Cervical Lordosis Angle Measured on Lateral Cephalograms; Findings in Skeletal Class II Female Subjects With and Without TMD: A Cross Sectional Study

Michele D'Attilio, D.D.S.; Ettore Epifania , D.D.S.; Fabio Ciuffolo, D.D.S.; Vincenzo Salini, D.D.S.; Maria Rita Filippi, M.D., D.D.S.; Marco Dolci, M.D.; Felice Festa, M.D., D.D.S., M.S., Ph.D.; Simona Tecco, D.D.S.

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Address for reprint requests:
Dr. Simona Tecco
Via Le Mainarde 26
65121 Pescara
Italy
E-mail: simtecco@tin.it

ABSTRACT: The literature reports evidence of various types of correlations between cervical alterations and cervical pain, and the existence of cervical pain in subjects with temporomandibular joint internal derangement (TMD). The hypothesis of this study is that cervical lordosis angle (CVT/EVT angle) alteration on cephalometrics could be correlated to the presence of TMD. The cephalometric records of 50 females with documented TMD were compared with those of a control group of 50 females. The subjects in the sample were 25-35 years of age, average 28.9 years (SD, 3.2). Radiographs were taken in mirror position, and seventeen variables, including the CVT/EVT angle, were traced. Double measurements were made to evaluate method error using Dahlberg's formula. Pearson's correlation coefficient and Mann-Whitney's *t*-test were used to evaluate the data. Intra-group analysis showed significant correlations between the CVT/EVT angle and mandibular length ($p<0.01$), mandibular position ($p<0.05$), mandibular divergence ($p<0.01$), and overjet ($p<0.01$) in both groups. Between groups, the analysis showed significant differences in CVT/EVT angle ($p<0.05$), maxillary protrusion ($p<0.01$), mandibular protrusion ($p<0.01$), mandibular length ($p<0.01$), mandibular divergence ($p<0.05$), and overbite ($p<0.05$).

Dr. Michele D'Attilio *received his D.D.S. degree in 1987 from the Faculty of Dentistry, University of L'Aquila, Italy. He has been a researcher in the Department of Orthodontics at the University of Chieti, Italy, since 2000 and is chairman of Orthodontics I. Dr. D'Attilio has written many clinical and research articles.*

The anatomy of cervical vertebrae and their relative position have attracted attention because a number of authors have proposed developmental associations between different variables indicative of cervicovertebral anatomy and dentofacial build. The greater part of longitudinal and cross-sectional studies are about the cervical column, are based on cephalometric tracings and focused on two types of observations: anatomical details of cervical vertebrae[1-9] (usually morphological features of the first and second vertebra) and variables describing postural position of the cervical column.[10-23]

Cervical posture was previously related to different factors, concerning general aspects of the body (ethnic origin,[1,9,18] sex,[1-20] age[15] and stature[22]), craniofacial morphology[10-23] (usually mandibular divergence,[15] mandibular size,[21] and facial shape[23]), functional factors (nasorespiratory function[1,13,22-26]) and orthodontic therapy (the use of removable orthodontic appliances or removable splints to increase vertical occlusal dimension.[27]

With regard to ethnic variations, for example, Solow[1] illustrated that in a group of young adult Australian Aboriginal males, the upper cervical column was inclined more anteriorly than in a matched control group of young Danish adult males. In a study about sexual dimorphism, Cooke and Wei1[18] compared young Caucasian males and females and young Chinese males and females and found that the Caucasian females had a somewhat larger cranio-cervical angulation than the males of the same age. Whereas, both the Caucasian and Chinese females had a more forwardly inclined cervical spine than the males. Hellsing,[15-16] while studying a group of 125 children (aged 8, 11 and 15 years), found not only a decrease in the cervical lordosis angle (CVT/EVT angle) but also an increase of thoracic kyphosis and lumbar lordosis in both genders with increasing age. More importantly, they found a highly significant correlation between thoracic and lumbar curvature development, while there was no correlation found between CVT/EVT angle and thoracic kyphosis. These results suggest that the curvature of the cervical spine develops closely in unison with the cranio-facial complex and not with the rest of the spine. Cervical posture is also associated with height,[22] as the taller the subjects were, the more forward was the inclination of their cervical columns; with craniofacial morphology,[10-23] predominantly mandibular length, the longer the mandible was, the more inclined was the cervical column to the true horizontal[21]; with mandibular divergence, negatively correlated to CVT/EVT angle[15]; with the face shape,[23] since subjects with a long dolichocephalic face had a straight, long, forwardly inclined cervical column, whereas brachycephalic subjects usually had increased lordosis of the spine.

Cervical posture was also related to nasorespiratory function[1,13,22-26]; Linder and Aronson[24-25] showed that the craniofacial morphology and cervical posture of children with no upper airway obstruction differed systematically from those of adenoidal children, since they had a larger craniocervical angle; however, it was noted that after an adenoidectomy, the difference disappeared so that the average craniofacial morphology of adenoidal children approached that of a control group. Solow[13] observed in a group of twenty-four children, between the ages of seven to nine years, that obstructed nasopharyngeal airways were connected with a larger craniocervical angle and with smaller mandibular dimensions, mandibular retrognathism and with a larger mandibular inclination.

This review of the literature is important primarily for three reasons: 1. it clearly shows that cervical posture can be influenced by many differing factors; 2. it gives rise to a necessity for careful selection of subjects in the study population, when a researcher is going to study cervical posture in a particular sample; and 3. it underscores the fact that none of the studies regarding cervical column posture focused on an evaluation of cervical posture in subjects with temporomandibular joint dysfunction (TMD). For this, the authors evaluated the cervical lordosis angle (CVT/EVT angle) in subjects with and without TMJ disk displacement.

The importance of evaluating the CVT/EVT angle in subjects with TMJ disk displacement and comparing these values to a control group concerns two different aspects.

From a research point of view, previous studies analyzed craniofacial morphology on lateral skull radiographs in subjects with temporomandibular joint disorders (TMD). But none of these studies introduced variables indicative of cervical posture. Stringert and Worms[28] evaluated facial morphological features in 60 TMD subjects and showed a prevalence of occlusal class II, division II among subjects with TMD, although this prevalence was not significant. They also observed that among subjects with no history of trauma associated with their TMD, prevalence of a larger mandibular angle (GoGn-SN) was higher than in a control group. It should be noted that the control group was taken from a previous study and there was no evidence provided for the absence of TMD in the control group subjects. Brand[29] showed a statistically significant smaller mandible in subjects with TMD than in an asymptomatic group. Nebbe[30] showed, in a cross-sectional pilot study on 25 adolescents (mean age 12.8, range 10 to 17), females and males, a negative significant relationship ($p<0.01$) between angular transformation of disk displacement and vertical ramus height (Co-Go); and between posterior facial height (S-Go) and divergence angle (SN/Go-Me). Bosio[31] showed that subjects with bilateral disk displacement had a statistically significant smaller SNB angle than the groups without disk displacement. None of these studies focused on variations in cervical posture.

From a clinical point of view, the literature reports a series of correlations between cervical lordosis alterations and cervical pain. McRae[32] showed that roentgenographic examination of the cervical spine revealed the existence of pathologic disorders in asymptomatic as well as in symptomatic subjects, and that neck pain, tenderness, limitation of neck mobility, poor reflexes or strength, and loss of sensation may or may not accompany a cervical pathological disorder. Kantor and Norton[33] observed that the normal lordotic curve could be altered as a result of cervical muscle spasms that cause the patient to hold the head in a different position in order to reduce pain and discomfort. However, it has been suggested that subjects with a craniomandibular disorder (CMD) more often suffer from a cervical spine disorder (CSD) with cervical pain,[34-37] and it is estimated that one-third of the TMD cases have cervical anomalies, such us upper cervical anomalies (atlanto-occipital fusion, anomalies of the odontoid process, or anomalies of the transverse ligament) at a young age and that this can lead to instability and neurological problems secondary to minor trauma), or lower cervical anomalies (degenerative arthritis that occurs in adults).[38-39] These studies, based on the coexistence between cervical spine disorders (CSD) and craniomandibular disorders (CMD), and including a non-patient control group, indicated that CMD subjects more often show signs and/or symptoms of CSD than control subjects.[33-37,39] The results of those studies are difficult to interpret, because of the differing examining techniques, such as questionnaires[34-35,37] and various clinical tests[34-36] to establish the presence of the cervical disorders.

The aim of this study was to evaluate the existence of a significant relationship between morphological features of subjects with TMJ disk displacement and CVT/EVT angle. The hypothesis on which this investigation is based is that in subjects with TMJ disk displacement, the altered mandibular position (evaluated in relation to anterior cranial base or simply on mandibular length) could influence a postural adoption of cervical lordosis, which eventually could give rise to cervical complaints in subjects with TMJ disk displacement.

In this study the authors evaluated the existence of a significant correlation between CVT/EVT angle and craniofacial morphological features in subjects with TMJ disk displacement. If a statistically significant correlation could be found in subjects with TMJ disk displacement and not in a control group, the orthodontist might then better understand the existence of cervical problems in subjects with certain skeletal formations. The primary purpose was to test the following null hypothesis: There is no difference in the incidence or severity of skeletal and dental patterns between a sample of subjects with TMJ disk displacement and a matched control sample without TMJ disk displacement.

Materials and Methods

The sample was comprised of 50 females, aged 25-35 years, average 28.6 (SD=3.3 yrs.), admitted to the Department of Orthodontics and Gnathology, University of Chieti, for treatment of TMD. The criteria for selection were: European ethnic origin, confirmed birth date, unilateral or bilateral TMJ disk displacement, skeletal II class (skeletal class was measured using standard methods), normal angle of mandibular rotation (GoGn/SN angle 32˚+/-6˚),[40] and height (measured in cm) between 160 and 170 cm. None of the women had any general joint disorders (e.g., rheumatoid arthritis); neither were they receiving nor had they undergone orthodontic treatment and/or orthognathic surgery in the past nor had any history of jaw fractures. All subjects had either undergone adenoidectomy before the age of ten years or had never shown adenoid pathologies. They were examined for current problems associated with nasal obstructions, active symptoms of head, neck, and facial pain, with the result that none were affected.

The 50 control females, aged 25-35 years, average 29.3 (SD=3.2 yrs.), were selected from a group of volunteers using the same stated criteria except that they had no TMJ disk displacement or cervical pain. Each subject of the control group signed a consent form permitting investigation and then underwent a standardized TMJ clinical examination. Subjects in the control group also agreed to undergo a free lateral skull radiograph because they were interested in an orthodontic evaluation and because they were offered in exchange, free panoramic radiographs. The Institutional Review Board approved this research based on an understanding that the control subjects had to undergo lateral skull radiographs for reasons independent of this research. Finally, two control subjects were asked to undergo a free magnetic resonance imaging (MRI) of the TMJ and all the subjects were given free dental services in exchange for their participation.

Assessment of Cervical Range and Pain

Subjects were screened for normal, pain free, cervical range of motion according to the detailed procedure reported by Visscher[41] (dynamic/static test). The evaluation revealed neck and shoulder pain in all the subjects in the test group. All the subjects revealed the point of pain on a 5-point verbal analog scale (VAS), but the population was not matched for the different values of the scale because this evaluation will be a part of a future investigation. The physical examination of the neck was considered positive when the subject rated the pain intensity of at least one of the dynamic/static tests equal or higher than 1-point verbal scale (which corresponds to the sensation of pressure without pain). Otherwise, the physical examination of the masticatory system or neck was considered negative. No evaluation was made on the basis of any history of oral pain. Physical examination of the neck area was made by two calibrated physical therapists. None of the subjects from the control group tested positive to the test for cervical pain.

Assessment of TMJ Disk Displacement

Subjects were selected consecutively from patients referred to the TMJ clinic for diagnosis and treatment of

TMD. They were included in the TMD group only if they presented TMJ disk displacement signs and symptoms.[42-43] Otherwise, they were included in the control group. Each subject from the two groups signed a consent form permitting investigation and underwent a standardized TMJ clinical examination, magnetic resonance images (MRI), and lateral skull radiographs.

During the clinical examination, the following clinical parameters were examined: facial symmetry; normal range of mandibular movement (protrusive, horizontal and vertical, in millimeters); opening patterns; type and stage of opening and closing joint sounds detected on auscultation; angle classification of dental malocclusion (the molar relationship was recorded for each side using a molar intermaxillary discrepancy greater than one-half cusp width to determine classes II and III; unilateral class II and III relationships were classified as class II and class III, respectively); canine or group lateral excursive movements; overbite; overjet (overbite and overjet were assessed using standard methods); and tenderness or pain of the muscles of mastication or the TMJ upon palpation. Subjects with unilateral TMJ disk displacement were also included in the sample.

For all the subjects, in both the test and control group, bilateral, high resolution, surface-coil, magnetic resonance images with a 1.5 Tesla magnetic resonance imaging unit were taken at the Villa Pini Clinica, Pescara, Italy. A 6.5 cm magnetic resonance surface-coil receiver was attached to a wooden frame that allowed the coil to be pressed against the temporal region. The magnetic resonance images were obtained in sagittal and transverse planes for both open and closed mouth positions. The images were interpreted by an oral radiologist, blind to the group classification, who classified each TMJ as having normal disk position, disk displacement with reduction or disk displacement without reduction using previously described methods.[44] The same oral radiologist repeated this classification approximately six months later in order to assess any error due to the observation. None of the MRIs were classified as different from the first evaluation.

Subjects in the control group were included in the investigation if they had:

a. Skeletal class II, assessed on cephalometric by using ANB angle (**Tables 1**, **2**, **3**);
b. No history of muscle or joint pain or tenderness;
c. No history of joint noise;
d. Demonstration of smooth, symmetrical mandibular movements;
e. Maximum opening of 40 mm or greater;
f. Maximum lateral movements of 10 mm or greater;
g. No evidence of internal derangement of the TMJ as determined by MRI; and
h. No tenderness of the muscles of mastication or of TMJ upon palpation.

Subjects were not excluded based upon any variations in dental occlusion.

Roentgenographic Technique for Lateral Skull Radiographs

Lateral skull radiographs were taken using Orthoceph 10E (Siemens AG, Germany), whose vertical adjustability allows the recording of standing subjects. The x-ray source had a focus of 0.6 mm. Exposure data were 80-86 KV and 32 mAs. The equipment had a fixed film to focus plane distance of 190 cm and a fixed film to midsagittal plane distance of ten cm, with a final enlargement of 10%. For all subjects 18x24 cm films were used. The head was oriented by a fiber-optic light beam to maintain the midsagittal line in a vertical plane at ten cm from the cassette and 180 cm from the focus median plane of the x-ray source. An examiner, blind to the group classification, standing behind the subject, corrected any deviation of the head and neck relative to the alignment of the light beam. This procedure allowed the examiner to maintain a fixed distance of the midsagittal plane of the head to the x-ray source and cassette. This ensured a constant enlargement of 10% of the midsagittal plane and thus permitted precise analysis of linear and angular dimensions. A 0.5 mm lead wire, suspended by weight, was mounted in front of the cassette in order to indicate true vertical on the film. A 20x100 cm mirror was placed on the wall 150 cm in front of the ear rods to allow recording of the natural head posture with external reference.[10] The recordings were carried out between 8:00 am and 2:00 pm. The radiographs were exposed with the subjects standing in ortho-position,[45] (the most reproducible, natural standing body position) defined as the intentional position from standing to walking. In order to minimize external influence, no ear rods were used in the cephalostat. The mirror position[10] was carried out only after the head had been placed in the self-balanced position.[10,46] The radiologist was asked to register on lateral skull radiographs all the neck and the sixth cervical vertebra.

Cephalometric Tracings

Thirty reference points (**Table 1, Figure 1**) were marked directly on each film with a soft sharp pencil (Propelling Pencil 0.5, Everflow Pen. Co., Langport, Somerset. TA 10 9RB). Twenty seven points were in the craniofacial area and three points were in the cervical column area. In order to make the determination of these points easy, the drawing is of the full neck area. Many different techniques appear in the literature for drawing

Table 1
Reference Points*

1.	Se:	Middle point of Sella opening
2.	S:	Sella point
3.	A:	A point
4.	B:	B point
5.	Pog:	Pogonion point
6.	Me:	Menton point
7.	N:	Nasion point
8.	Ar:	Articulare point
9.	Gn:	Gnation point
10.	cv2tg:	Tangent point of the superior, posterior extremity of the odontoid process of the second cervical vertebra
11.	cv2ip:	Most inferior-posterior point on the body of the second cervical vertebra
12.	cv4ip	Most inferior-posterior point on the body of the fourth vertebra
13.	cv6ip	Most inferior-posterior point on the body of the sixth vetebra
14.	Go:	According to Schwarz, the point of intersection between RL (ramus line) and ML (mandibular line)
15.	T1:	Posterior tangent point of mandibular line and anterior to the gonial area
16.	T2:	Lower tangent point of ramus line and superior to the gonial area
17.	E:	Orthogonal projection of the posterior point of condylar head on the SN plane
18.	L:	Orthogonal projection of pogonion point on the SN plane
19.	vpUK:	Orthogonal projection of pogonion on mandibular line
20.	vpOK:	Orthogonal projection of A point on spinal plane
21.	Rasc:	Point of intersection between ramus line and H line, according to Schwartz
22.	snp:	Posterior spinal point
23.	sna:	Anterior spinal point
24.	Po:	Porion point
25.	Or:	Orbital point
26.	Ini +	Upper incision point
27.	Ini -	Lower incision point
28.	I +	Coronal point of upper incision
29.	I -	Coronal point of lower incision

*Table lists reference points shown on lateral skull radiograph (**Figure 1**).

the cervical spine as it is seen in lateral skull films and cephalograms.[47-50] On the tracing, the neck area was traced according to the instructions of Vastardis and Evans[39] Thirteen references lines, described in **Table 2**, were considered. The variables studied are listed in **Table 3** and shown in **Figure 2**. Craniofacial morphological variables were traced according to Schwarz[51] and the CVT/EVT angle according to Hellsing.[15]

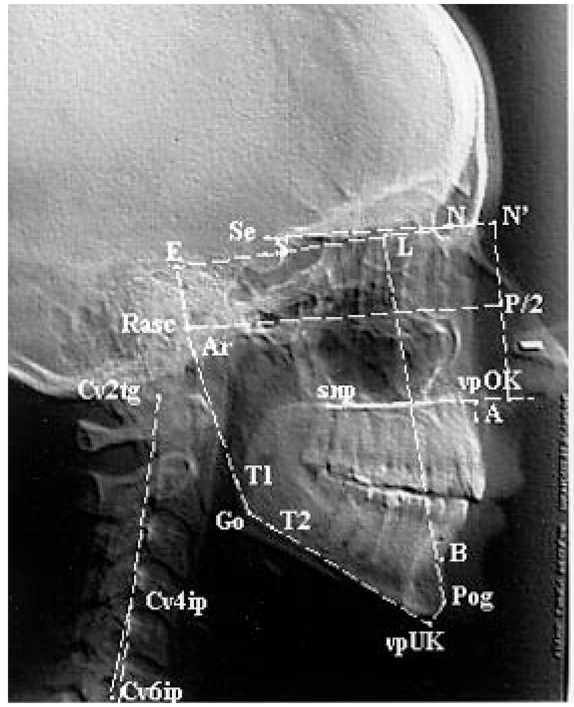

Figure 1
Reference points and lines on a lateral skull radiograph.

Error Method

In order to assess errors due to landmark identification, duplicate measurements were made of 15 radiographs, as described by Hellsing[15-16] and shown in **Figure 2**, **Table 4**. Variables were compared for each registration and the error variance was calculated using Dahlberg's formula[52]:

$$\delta = \sqrt{(\sum d^2/2N)}$$

where d is the difference between the first and second measurements and N the number of double registrations.

Statistical Analysis

Microsoft Excel 2000 (Microsoft, Inc.) software and the Statistical Analysis System (SAS) package (SAS Institute, Cary, N.C. USA)[53] were employed to perform the data analysis. Statistical data, including means, standard deviations (SD), medians, 25th and 75th percentiles, and range, were computed for each morphological variable. The bivariate relationships between variables was

Table 2
Reference Lines*

1.	SN:	Nasion-sella line; line through N and S
2.	SeN:	Anterior cranial base line; according to Schwartz
3.	NA:	Nasion to A point; line through N and A
4.	NB:	Nasion to B point; line through N and A
5.	FH:	Frankfort horizontal; line from Po to Or
6.	PN:	Nasal perpendicular line, according to Schwartz, perpendicular line to SeN through N
7.	PN/2:	Middle point of PN; line from N and perpendicular to snp-sna
8.	sna-snp:	Palatal plane (PP); line through sna and snp
9	GoGn:	Line through Go (anatomical point) and Gn (anatomical point)
10.	ML:	Mandibular line; line through Me and T2
11.	RL:	Ramus line; line through Ar and T1
12.	H:	Parallel line to SeN; through PN/2
13.	CVT:	Upper part of cervical spine; line through cv2tg and cv4ip
14.	EVT:	Lower part of cervical spine; line through cv4ip and cv6ip
15.	OPT:	Odontoid line; line through cv2tg and cv2ip
16.	Overjet:	Distance between I+ and I- projections on occlusal plane
17.	Overbite:	Distance between I+ and I- projections perpendicular line to occlusal plane
18.	Go-Rasc:	Ramus height; line through Go and Rasc
19.	VER:	True vertical line; vertical line projected on the film

*Table lists reference lines shown on lateral skull radiograph (**Figure 1**)

Table 3
Variables Studied*

1.	SNA:	Angle between S, N, and A points
2.	SNB:	Angle between S, N, and B points
3.	ANB:	Angle between NA line and NB line
4.	CVT/EVT:	Cervical lordosis angle; downward opening angle between the CVT/EVT line
5.	OPT/Ver:	Odontoid angle; downward opening angle between OPT and True Vertical lines
6.	EVT/Ver:	Lower cervical column angle; downward opening angle between EVT and True Vertical lines
7.	CVT/Ver:	Upper cervical column angle; downward opening angle between CVT and True Vertical lines
8.	Go-Gn/SN:	Craniomandibular angle; angle between Go-Gn and SN lines
9	E-L:	Mandibular length, according to Steiner; distance between E and L points in mm
10.	Go-VpUK:	Mandibular length, according to Schwartz; distance between Go and vpUK
11.	snp-vpOK:	Maxillary length, according to Schwartz; distance between snp and vpOK
12.	Se-N:	Anterior cranial base length, according to Schwartz; distance between Se and N
13.	Rasc-Go:	Ramus height, according to Schwartz; distance between Rasc and Go points
14.	Overjet:	Distance between I+ and I- projections on the occlusal plane
15.	Overbite:	Distance between I+ and I- projections on a perpendicular line to occlusal line
16.	FM:	Angle between FH and Go-Gn
17.	MM:	Angle between sna-snp and Go-Gn

*Table lists morphological and postural variables traced on lateral skull radiograph (**Figure 1**)

tested with the 2-tailed Pearson's R coefficients.[54] The corresponding square values of the Pearson's R coefficient(r^2) were also reported, as a linearity index of associations. Moreover, for each considered association, the null hypothesis was tested and the 5% level was used to assess the statistical significance.

Between the experimental and control groups, differences in central tendency of angular and linear measurements were tested using the Mann-Whitney *t* test, corrected for great samples with Z_t, for normally distributed values of *t* coefficient and corrected for ties.[55] The *p* values were calculated for each of the variables with a level of significance for each test established at 0.05.

Results

Patient Demographics

The minimum age was 25 years and the maximum age was 35 years for both groups. The mean age for the experimental group was 28.6 years (SD=3.4). The control mean was 29.3 years (SD=3.2). Both groups combined had a mean age of 28.9 years (SD=3.2).

Statistical Data

All subjects included in this study were in skeletal class II. In the test group, orthodontic classification showed that 18 subjects (36%) were class II, division I and 32 (64%) were class II, division II. In the control group, orthodontic classification showed that 32 subjects (64%) were class II, division I and 18 (36%) were class II, division II. The statistics include mean value, SD, 25th and 75th percentiles and range performed for the test group (**Table 5**) and for the control group (**Table 6**).

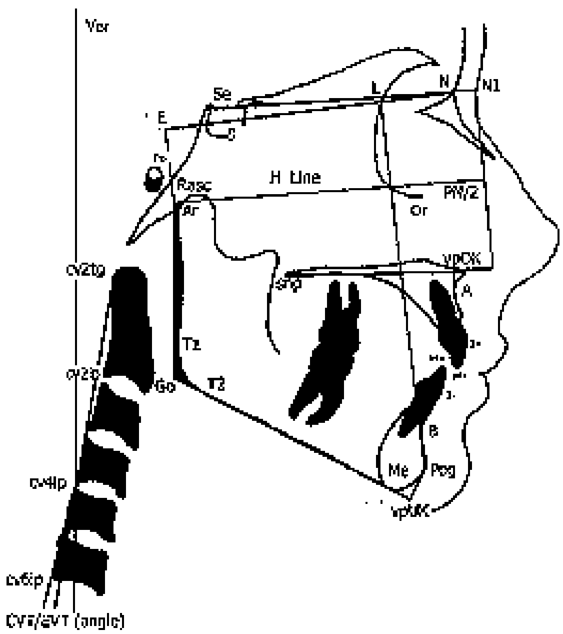

Figure 2
Cephalometric tracing.

Clinical Examination of the TMJ

All subjects in the test group showed uni- or bilateral TMJ disk displacement. The most common symptoms of TMD recorded in the sample were: localized pain in the TMJ or ear; pain during mandibular movement; headaches aggravated by jaw movement; presence of joint sounds (on the basis of history and physical examination); limited mandibular range of vertical opening (<40 mm) and horizontal (<5 mm) movements; deviation on mandibular opening; tenderness and pain to palpation of jaw closure muscle bilaterally; and history of locking.

Interpretation of MRIs

Among subjects in the test group, MRIs revealed that eleven subjects (22%) had unilateral disk displacement with reduction and normal disk position in the contralateral TMJ. There was one subject (2%) with one disk displacement without reduction and the other joint with normal disk position; 21 subjects (42%) had bilateral disk displacement with reduction; 13 subjects (26%) had bilateral disk displacement without reduction; and four subjects (8%) had one disk displacement that reduced, whereas the other did not. All the control subjects were interpreted as having normal disk position bilaterally.

Measurement Error

When errors in landmark localization during retracing and redigitization were evaluated, the difference in the means revealed that the error from both sources was less than 0.5° for all angular measurements and less than 0.5 mm for all linear measurements (**Table 4**).

Correlation Between CVT/EVT Angle and Morphological Face Variables

Postural variables of the cervical column were significantly associated with many of the morphological variables of the face, in both groups (**Table 7**). The most important findings concerned three aspects: 1. the relationship between postural variables and mandibular size; 2. the relationship between postural variables and mandibular divergence; and 3. the relationship between postural variables and overjet.

The CVT/EVT angle was significantly associated with mandibular length (Go-vpuK) (p<0.001 in both groups), i.e., the longer the mandible was, the lower the CVT/EVT angle. The OPT/Ver and CVT/Ver (represents the upper segments of the cervical column, **Tables 1**, **2**, and **3**) showed a significant positive association with mandibular length (p<0.001 in the TMD group and p<0.05 in the

Table 4
Method Errors*

Variable	S(i)**	s(i) as % of total sample variance (two groups) (n=100)
SNA	.52	2.87
SNB	.43	1.87
ANB	.68	47.53
CVT/EVT	.62	1.43
GoGn/SN	.52	1.75
FM	.60	2.71
MM	.61	3.74
EL	.62	.52
SeN	.70	3.51
Snp-vpOK	.62	1.46
Go-vpUK	.52	.68
OPT/Ver	.51	.50
CVT/Ver	.45	.69
EVT/Ver	.44	.25
Overjet	.33	4.93
Overbite	.26	4.12
Go-Rasc	.58	3.10

* Table shows results of error method analysis
** $s(i) = \sqrt{}\,(\sum d^2/2n$, where *d* represents the difference between double determinations of the same subject and *n* is the sample size (n=15)

Table 5

Descriptive Statistical Data for the TMD Group (n=50)*

Variable	Mean	SD	25th percentile	Median	75th percentile	Range
Skeletal relations						
SNA (degree)	80.49	2.84	79.00	80.50	82.00	74.0-85.5
SNB (degree)	75.42	2.98	74.13	80.50	82.00	69.0-81.0
ANB (degree)	5.07	0.86	79.00	80.05	82.00	4.5-9.0
Cervical variables						
CVT/EVT (degree)	7.96	5.11	4.00	7.00	9.75	2.0-30.0
OPT/VER (degree)	-0.92	7.18	-8.00	-1.50	5.00	21.5-38.0
CVT/VER (degree)	-0.94	5.21	-5.00	0.00	3.00	20.0-34.0
EVT/VER (degree)	-8.90	9.31	-13.63	-7.50	-2.00	21.0-33.0
Mandibular size						
Go-vpUK (mm)	80.28	3.76	78.00	81.00	83.00	46.0-83.0
EL (mm)	63.70	8.89	56.25	65.00	70.75	65.0-77.0
Go-Rasc (mm)	49.74	3.36	47.25	49.00	51.00	43.5-75.0
Maxillary size						
snp-vpOK (mm)	50.50	4.97	47.50	50.50	52.88	70.0-85.5
Vertical variables						
Go-Gn/SN (degree)	32.86	3.70	32.00	33.50	35.50	21.5-38.0
FM (degree)	27.96	3.34	25.00	29.00	30.00	20.0-34.0
MM (degree)	28.84	3.15	26.25	29.00	32.00	21.0-33.0
Cranial base size						
Se-N (mm)	69.96	3.34	67.00	70.00	71.00	65.0-77.0
Dental variables						
Overjet (mm)	3.61	1.15	3.00	3.50	4.00	1.0-6.0
Overbite (mm)	3.47	1.12	3.00	3.00	4.00	1.0-6.0

*Table lists descriptive statistical data for morphological and postural variables in the TMD group (n=50)

control group). This seems to suggest that the increase in the CVT/EVT angle was caused by the back inclination of the upper segment of cervical column. At the same time, since EVT/Ver (represents the lower segment of the cervical column, **Tables 1**, **2**, and **3**) also showed a significant association with mandibular length ($p<0.001$ in both groups), it seems to suggest that the increase in the CVT/EVT angle was also caused by a forward inclination of the lower segment of the cervical column.

The CVT/EVT angle was significantly associated with mandibular divergence (GoGn/SN) ($p<0.001$ in both groups) since the more divergent the mandible was, the lower was the CVT/EVT angle. Also, since the EVT/Ver (**Tables 1**, **2**, and **3**) showed a positive significant association with mandibular divergence (GoGn/SN) ($p<0.001$ in TMD group; $p<0.05$ in control group) and with FM angle ($p<0.05$ in both groups), it seems to suggest that the change in the CVT/EVT angle was mostly due to a forward inclination of the lower segment of the cervical column.

Finally, the CVT/EVT angle was significantly correlated to overjet ($p<0.001$ in both groups) as the greater the overjet was, the higher was the CVT/EVT angle. As EVT/Ver (**Tables 1**, **2**, and **3**) showed a significant correlation with overjet ($p<0.001$ in both groups), this suggests that the lower segment of the cervical column is responsible for the changes due to overjet.

Correlation Between Morphological Face Variables

Correlations between morphological variables were reported for both groups in **Table 8**. The most important findings concerned three aspects: 1. the relationship among the variables indicating mandibular size and shape; 2. the relationship between maxillary and mandibu-

Table 6
Descriptive Statistical Data for the Control Group (n=50)*

Variable	Mean	SD	25th percentile	Median	75th percentile	Range
Skeletal relations						
SNA (degree)	83.00	2.79	80.63	83.00	85.00	77.5-88.5
SNB (degree)	77.85	2.77	76.00	78.00	80.00	72.5-82.5
ANB (degree)	5.15	1.09	4.50	5.00	5.00	4.0-9.50
Cervical variables						
CVT/EVT (degree)	9.68	5.11	6.13	9.25	12.80	0.5-26.0
OPT/VER (degree)	-0.50	7.27	-6.00	-2.00	5.00	-12.0-11.0
CVT/VER (degree)	-0.57	5.77	-5.75	-0.75	4.00	-10.0-8.00
EVT/VER (degree)	-10.16	8.23	-15.88	-11.25	-3.25	-24.0-6.0
Mandibular size						
Go-vpUK (mm)	76.46	7.67	75.20	78.00	81.00	52.0-86.0
EL (mm)	70.16	6.95	65.38	71.50	75.75	53.0-82.5
Go-Rasc (mm)	51.12	3.13	48.25	51.00	54.00	45.0-56.0
Maxillary size						
snp-vpOK (mm)	51.01	5.28	47.63	50.00	53.00	42.0-66.0
Vertical variables						
Go-Gn/SN (degree)	31.42	4.05	28.25	31.05	34.00	25.0-38.0
FM (degree)	25.86	3.66	22.25	26.00	28.75	20.0-32.0
MM (degree)	27.26	2.88	26.00	28.00	29.00	23.0-32.0
Cranial base size						
Se-N (mm)	71.09	4.12	68.00	71.00	73.00	42.0-66.0
Dental variables						
Overjet (mm)	3.19	1.78	2.00	3.00	5.00	0.0-6.0
Overbite (mm)	2.91	1.35	2.00	3.00	4.00	0.0-5.5

*Table lists descriptive statistical data for morphological and postural variables in the Control group (n=50)

lar base; and 3. the relationship between the lower third of the face and the upper third.

Mandibular length (Go-vpUK) showed a significant positive correlation with mandibular divergence (GoGn/SN) ($p<0.05$ in both groups), as the longer the mandible, the more divergent it was. However, EL variable (represents the length of mandible measured as orthogonal projection on anterior cranial base, as seen in **Tables 1**, **2**, and **3**) was negatively correlated to mandibular divergence ($p<0.05$ in both groups). This result is probably due to the geometrical construction of EL variable: as the GoGn/Sn angle increased, the orthogonal projection of Pog point and of the posterior point of the condylar head on SN (L point and E point, respectively) are more nearly located. Another important finding was that in the control group, variables indicating mandibular size (EL and Go-vpUK) and position (SNB) showed a correlation between EL and Go-vpUK ($p<0.05$) and SNB and EL ($p<0.05$). Also in the TMD group, the variables SNB and EL showed a highly significant correlation ($p = 0.001$). In both groups the variables SNB and Go-vpUK showed no correlation.

Mandibular length (EL) correlated positively with mandibular sagittal position (SNB) ($p<0.001$ in TMD group; $p<0.05$ in control group), as well as maxillary length (snp-vpOK) and maxillary sagittal position (SNA) ($p<0.01$ in TMD group; $p<0.001$ in Control group). With regard to the intermaxillary relationship, the mandibular sagittal position (SNB) result was positively correlated to maxillary length (snp-vpOK) ($p<0.05$ in TMD group; $p<0.05$ in control group).

Finally, a close relationship was found between morphological features of the lower third of the face and the upper third, as maxillary length (snp-vpOK) correlated

Table 7

Correlation Results Between Postural and Morphological Variables of the Two Groups (n=50)

Variable Associations	TMD group Correlation coefficient	TMD group r^2	TMD group Significance	Control group Correlation coefficient	Control group r^2	Control group Significance
CVT/EVT SNA	0.284	0.081	0.019*	-0.061	0.004	0.096
CVT/EVT SNB	0.284	0.081	0.019*	-0.283	0.080	0.020*
CVT/EVT ANB	-0.046	0.002	0.098	0.563	0.317	0.000**
OPT/Ver SNA	-0.163	0.027	0.073	-0.048	0.002	0.098
OPT/Ver SNB	-0.118	0.014	0.086	-0.051	0.003	0.097
OPT/Ver ANB	-0.132	0.017	0.083	0.006	0.000	0.100
CVT/Ver SNA	-0.132	0.017	0.083	-0.046	0.002	0.098
CVT/Ver SNB	-0.085	0.007	0.093	-0.050	0.002	0.098
CVT/Ver ANB	-0.143	0.020	0.080	0.008	0.000	0.100
EVT/Ver SNA	-0.230	0.053	0.047*	0.001	0.000	0.100
EVT/Ver SNB	-0.204	0.041	0.059	0.138	0.019	0.081
EVT/Ver ANB	-0.054	0.003	0.097	-0.349	0.122	0.000**
CVT/EVT Go-vpUK	-0.499	0.249	0.000**	-0.420	0.177	0.000**
OPT/Ver Go-vpUK	0.477	0.227	0.000**	0.372	0.138	0.000**
CVT/Ver Go-vpUK	0.532	0.283	0.000**	0.297	0.088	0.012*
EVT/Ver Go-vpUK	0.572	0.327	0.000**	0.466	0.217	0.000**
CVT/EVT EL	0.291	0.085	0.015*	-0.251	0.063	0.037*
OPT/Ver EL	-0.147	0.022	0.078	-0.100	0.010	0.090
CVT/Ver EL	-0.085	0.007	0.093	-0.066	0.004	0.096
EVT/Ver EL	-0.207	0.043	0.057	0.128	0.016	0.084
CVT/EVT Go-Rasc	0.025	0.001	0.099	0.209	0.044	0.056
OPT/Ver Go-Rasc	0.297	0.088	0.012*	-0.211	0.045	0.055
CVT/Ver Go-Rasc	0.230	0.053	0.047*	-0.179	0.032	0.068
EVT/Ver Go-Rasc	0.115	0.013	0.087	-0.263	0.069	0.031*
CVT/EVT snp-vpOK	-0.214	0.046	0.054	0.285	0.081	0.019*
OPT/Ver snp-vpOK	0.067	0.005	0.095	-0.350	0.122	0.000**
CVT/Ver snp-vpOK	0.068	0.005	0.095	-0.279	0.078	0.022*
EVT/Ver snp-vpOK	0.156	0.024	0.076	-0.375	0.141	0.000**
CVT/EVT GoGn/SN	-0.378	0.143	0.000**	-0.378	0.143	0.000**
OPT/Ver GoGn/SN	0.091	0.008	0.092	0.134	0.018	0.082
CVT/Ver GoGn/SN	0.209	0.043	0.057	0.065	0.004	0.096
EVT/Ver GoGn/SN	0.324	0.105	0.000**	0.286	0.082	0.018*
CVT/EVT FM	-0.290	0.084	0.016*	-0.131	0.017	0.083
OPT/Ver FM	0.130	0.017	0.083	0.211	0.044	0.056
CVT/Ver FM	0.215	0.046	0.054	0.204	0.042	0.058
EVT/Ver FM	0.279	0.078	0.022**	0.230	0.053	0.047*
CVT/EVT MM	-0.192	0.037	0.063	-0.046	0.002	0.098
OPT/Ver MM	-0.053	0.003	0.097	0.206	0.043	0.057
CVT/Ver MM	0.054	0.003	0.097	0.152	0.023	0.077
EVT/Ver MM	0.136	0.018	0.082	0.142	0.020	0.080
CVT/EVT SeN	-0.174	0.030	0.070	0.193	0.037	0.063
OPT/Ver SeN	0.268	0.072	0.028*	-0.421	0.177	-0.000**
CVT/Ver SeN	0.264	0.070	0.030*	-0.391	0.153	0.000**
EVT/Ver SeN	0.243	0.059	0.041*	-0.408	0.166	0.000**
CVT/EVT Overbite	-0.233	0.054	0.046*	-0.061	0.004	0.096
OPT/Ver Overbite	0.182	0.033	0.067	-0.042	0.002	0.098
CVT/Ver Overbite	0.146	0.021	0.079	-0.010	0.000**	0.100
EVT/Ver Overbite	0.209	0.044	0.056	0.044	0.002	0.098
CVT/EVT Overjet	0.344	0.118	0.000**	0.344	0.118	0.000**
OPT//Ver Overjet	-0.167	0.028	0.072	-0.165	0.027	0.073
CVT/Ver Overjet	-0.246	0.060	0.040*	-0.158	0.025	0.075
EVT/Ver Overjet	-0.326	0.106	0.000**	-0.314	0.099	0.001**

* $p<0.05$ ** $p<0.01$

r^2: square of the Pearson's r correlation coefficient

Table 8

Correlation Results Between the Considered Morphological Variables of the Two Groups (n=50)

Variable Associations	TMD group Correlation coefficient	TMD group r^2	TMD group Significance	Control group Correlation coefficient	Control group r^2	Control group Significance
Mandibular size and position						
Go-vpUK SNB	-0.051	0.003	0.097	-0.010	0.000	0.100
Go-vpUK SNA	-0.014	0.000	0.100	-0.018	0.000	0.100
Go-vpUK ANB	0.133	0.018	0.982	-0.021	0.000	0.100
G0-vpUK snp-vpOK	0.160	0.026	0.074	-0.467	0.218	0.000**
Go-vpUK overjet	-0.431	0.185	0.000**	0.089	0.008	0.092
Go-vpUK overbite	0.259	0.067	0.033*	0.034	0.001	0.099
Go-vpUK EL	-0.159	0.025	0.075	0.227	0.052	0.048*
EL SNA	0.488	0.238	0.000**	0.146	0.021	0.079
EL SNB	0.466	0.217	0.000**	0.244	0.059	0.041*
EL ANB	-0.001	0.000	0.100	-0.244	0.060	0.040*
EL snp-vpOK	-0.153	0.024	0.076	0.216	0.047	0.053
EL overjet	0.209	0.044	0.056	0.011	0.000	0.100
EL overbite	-0.237	0.056	0.044	0.107	0.012	0.088
SNB snp-vpOK	0.268	0.072	0.028*	0.286	0.082	0.018*
SNB overjet	0.123	0.015	0.085	-0.033	0.001	0.099
SNB overbite	-0.149	0.022	0.078	0.058	0.003	0.097
Mandibular size and vertical dimension						
Go-vpUK GoGn/SN	0.264	0.069	0.031*	0.246	0.060	0.040*
Go-vpUK FM	0.259	0.067	0.033*	0.046	0.002	0.098
Go-vpUK MM	0.093	0.009	0.091	0.057	0.003	0.097
Go-vpUK GoRasc	-0.018	0.000	0.100	-0.052	0.033	0.097
EL GoGn/SN	-0.289	0.084	0.016*	-0.291	0.084	0.016*
EL FM	-0.036	0.093	0.007**	-0.283	0.080	0.020**
EL MM	-0.189	0.036	0.063	-0.408	0.166	0.000**
EL GoRasc	0.335	0.112	0.000**	0.363	0.131	0.000**
SNB GoGn/SN	-0.493	0.243	0.000**	-0.161	0.004	0.096
SNB FM	-0.510	0.260	0.000**	-0.052	0.003	0.097
SNB MM	-0.496	0.246	0.000**	-0.157	0.024	0.076
SNB GoRasc	0.342	0.117	0.000**	-0.060	0.004	0.096
Maxillary size and position						
snp-vpOK SNA	0.301	0.091	0.009**	0.336	0.113	0.000**
snp-vpOK ANB	0.067	0.004	0.096	0.134	0.018	0.082
snp-vpOK overjet	-0.133	0.018	0.082	-0.056	0.003	0.097
snp-vpOK overbite	-0.163	0.026	0.074	0.022	0.000	0.100
SNA overjet	0.148	0.022	0.078	0.118	0.014	0.086
SNA overbite	-0.116	0.013	0.087	0.155	0.024	0.076
Maxillary size and vertical dimension						
snp-vpOK GoGn/SN	0.084	0.007	0.093	-0.246	0.060	0.040
snp-vpOK FM	0.136	0.018	0.082	-0.214	0.046	0.054
snp-vpOK MM	0.031	0.001	0.099	-0.396	0.157	-0.057
snp-vpOK GoRasc	-0.121	0.015	0.085	0.173	0.030	0.070
SNA GoGn/SN	-0.512	0.263	0.000**	-0.125	0.016	0.084
SNA FM	-0.498	0.248	0.000**	-0.009	0.000	0.100
SNA MM	-0.516	0.266	0.000**	-0.108	0.012	0.088
SNA GoRasc	0.302	0.091	0.009**	-0.089	0.008	0.092

Table continued next page

Table 8 (cont.)
Correlation Results Between the Considered Morphological Variables of the Two Groups (n=50)

Variable Associations	TMD group Correlation coefficient	r^2	Significance	Control group Correlation coefficient	r^2	Significance
Anterior cranial base and morphological face variables						
SeN SNA	-0.016	0.000	0.100	-0.097	0.009	0.091
SeN SNB	-0.070	0.005	0.095	-0.115	0.013	0.087
SeN Go-vpUK	0.427	0.182	0.000**	-0.266	0.071	0.029*
SeN EL	-0.460	0.212	0.000**	0.272	0.074	0.026
SeN snp-vpOK	0.319	0.102	0.000**	0.489	0.239	0.000**
SeN overjet	-0.219	0.048	0.052	0.149	0.022	0.078
SeN overbite	0.139	0.019	0.081	-0.079	0.006	0.094
Anterior cranial base and vertical dimension						
SeN GoGnSN	-0.047	0.002	0.098	-0.305	0.093	0.007**
SeN FM	0.149	0.022	0.078	-0.340	0.115	0.000**
SeN MM	-0.077	0.006	0.094	-0.403	0.162	0.000**
SeN GoRasc	-0.019	0.000	0.100	0.468	0.219	0.000**
Overjet and overbite						
Overjet overbite	0.106	0.011	0.089	0.314	0.099	0.001**
Overjet GoRasc	0.026	0.001	0.099	0.007	0.000	0.100
Overbite GoRasc	0.066	0.004	0.096	-0.048	0.002	0.098

* $p<0.05$ ** $p<0.01$
r^2: square of the Pearson's r correlation coefficient

positively with anterior cranial base length (SeN) ($p<0.001$ in TMD group; $p<0.001$ in control group).

Group Differences

Differences between the groups are reported in **Table 9**. TMD subjects showed a significantly lower CVT/EVT angle than control subjects ($p<0.05$) and also a significantly lower mandibular and maxillary protrusion (SNA, SNB) than control ones ($p<0.001$). However, mandibular length (Go-vpUK) was significantly higher in the TMD subjects than in the control subjects ($p<0.01$). TMD subjects also showed a higher mandibular divergence (GoGn/SN angle), facial height (FM angle) and lower facial height (MM) ($p<0.05$; $p<0.01$; $p<0.01$ respectively) than the control subjects. Mandibular ramus height was significantly shorter in the TMD subjects than in the control subjects ($p<0.01$). Overbite was significantly higher in the TMD group than in the control subjects ($p<0.05$).

Discussion

The aim of this investigation was to evaluate the CVT/EVT angle without considering systematic effects of 1. race, 2. sex, 3. age, 4. mandibular inclination, 5. previous orthodontic treatment, and 6. airway adequacy problems which, according to previous observations by several authors,[1-22,24-27,56] could influence cervical posture. For this reason, the selection from the population was made carefully with regard to the criteria.

A physical examination was done to evaluate cervical pain, and oral history was not considered because Visscher[41] showed that the oral history, even if useful to individuate cervical spine pain subjects, cannot exclude people with pain complaints that do not originate from the muscles or joints. Instead, physical examination is likely to include persons with a certain cervical spine pain in the group; however, the limit to physical examination is that this method only gives a momentary impression of the status of the musculoskeletal structures, whereas the presence of pain can fluctuate over time. Physical examination of pain was made by using a dynamic/static test to show that this method is more useful to individuate cervical spine pain than palpation.[41,57] Pain intensity was indicated by the subjects as a score on a visual analogical scale (VAS) because according to Visscher,[41] this type of evaluation better discriminates between subject differences. Pain intensity is also dependent on psychological

Table 9
Differences Between Groups (n=50)

Variable	T	Z	Significance
SNA (degree)	3149.0	4.077	.000**
SNB (degree)	3063.0	3.720	.000**
CVT/EVT (degree)	2835.0	2.137	.033*
OPT/Ver (degree)	2487.5	.422	.673
EVT/Ver (degree)	2339.5	1.276	.202*
GoGn//SN (degree)	2235.5	1.997	.046*
FM (degree)	2125.0	2.767	.006**
MM (degree)	2138.5	2.677	.007**
SeN (mm)	2741.0	1.490	.136
Go-vpUK (mm)	2109.0	2.870	.004**
EL (mm)	3072.0	3.771	.000**
Snp-vpOK (mm)	2512.5	.083	.934
G0-Rasc (mm)	3027.5	2.629	.009**
Overjet (mm)	2348.5	1.232	.218
Overbite (mm)	2223.5	2.120	.034*

* p<0.05
** p<0.01
T: Mann-Whitney rank sum test (2 codes)
Z: Mann-Whitney rank sum coefficient for large samples (details in text)

factors, e.g., level of stress or anxiety, and is subjective.[58] Therefore, for this evaluation the VAS was not objective enough to evaluate the variable of pain intensity so that variable was not included in the statistical analysis.

The most significant finding in this study was that a straighter cervical lordosis (CVT/EVT angle) correlated with a great mandibular millimetric length (Go-vpUK) in both the test and control groups (p<0.001) (**Table 7**). Go-vpUK was also highly positively correlated to OPT/Ver (p<0.001 in both groups); to CVT/Ver (p<0.001 in TMD group; p<0.05 in control group); to EVT/Ver (p<0.001 in both groups) (**Table 7**). These results appear to suggest that the odontoid process (OPT line) and the upper segment of the cervical column (CVT line) showed a back inclination in subjects with long mandibles, while the lower segment of the cervical column (EVT line which, according to a normal lordotic curvature of the cervical spine, generally shows a negative angle with respect to the true vertical line) showed a forward inclination in subjects with long mandibles. Based on our results and on the occurrence of a long mandible (high values of Go-vpUK), while the back inclination of the OPT line and CVT line goes in the direction of an increase in the CVT/EVT angle (consequently to the increase in the CVT/Ver)—in the same way—the forward inclination of the EVT line goes in the direction of a decrease in the CVT/EVT angle. This observation seems to show evidence of different developmental behaviors of the upper and the lower segments of the cervical column. This agrees with a previous study[15] which referred to a different developmental origin for the upper and the lower segments of the cervical column.

Our results agree with those of Özbek[21] who showed, in a group of adult subjects without TMJ disk displacement, that the length of the mandible measured on cephalometric relative to the effective length of the maxilla and the anterior cranial base, showed statistically significant negative correlations (p<0.001) with the postural variables indicating the inclination of the cervical column to the true horizontal (OPT/Hor).

Another important finding in our study is that the CVT/EVT angle was highly correlated with mandibular divergence (GoGn/SN angle) (p<0.001 in both groups) (Table 7), since the more divergent the mandible, the lower the CVT/EVT angle. This conclusion is supported by another result of our study: EVT/Ver was positively correlated to GoGn/SN (p<0.001 in the TMD group; and p<0.05 in the control group) and to FM (p<0.05 in both groups). Why the two different results (negative correlation between CVT/EVT and GoGn/SN and positive correlation between EVT/Ver and GoGn/SN) are in accord with the same conclusion is explained above. In fact, according to the construction of the tracings, illustrated in **Table 3** and in **Figure 2**, an increase in the EVT/Ver angle directly resulted in a decrease in the CVT/EVT angle, so that, generally, a morphological variable negatively correlated to the CVT/EVT angle, such as GoGn/SN, could easily be positively correlated to the EVT/Ver angle. The association between an increas in facial anterior vertical dimension and the CVT/EVT angle agrees with previous findings.[15-16]

A further finding of the study concerns the correlation between postural variables and overjet, measured in mm. An increase in overjet resulted in an increase of the CVT/EVT angle (p<0.001 in both groups). This result is supported by another finding of the study. EVT/Ver was highly negatively correlated to overjet in both groups (p<0.001 in TMD subjects; p<0.01 in control group). These results seem to suggest that a clinical situation characterized by a large overjet and the possibility for the jaw to move in antero-posterior directions could be associated with an increase in the CVT/EVT angle. However, no conclusions are possible regarding the mechanism at work because of the cross-sectional method of this study.

Important findings of this investigation concern the differences between the groups with regard to the existence of statistically significant differences in postural as well as in morphological variables.

The mean value of the CVT/EVT angle was lower in the TMD group than in the control group (Z: 2.137; p<.05) (**Table 9**). This finding suggests that TMD could influence a decrease in the CVT/EVT angle. But this assumption can not be made using only cephalometric relationships and cross-sectional observations, because we do not know the value of the CVT/EVT angles before the onset of TMD. With regard to the alteration in cervical lordosis, Kantor and Norton[33] observed that the normal lordotic curve can be altered as a result of cervical muscle spasms that cause the patient to posture the head in an effort to reduce pain and discomfort. The reason may be found in the neurophysiological principles of convergence and sensitization.[59-60] A constant nociceptive input on second-order neurons may increase the sensitivity of these neurons. Then, non-nociceptive neural impulses from other areas within the same segment which converge into these neurons, may give rise to nociceptive sensations. For the craniocervical region, a constant nociceptive input from, for example, the upper part of the trapezius muscle can lead to an increased sensitivity of the spinal trigeminal nucleus. Non-nociceptive stimuli from the masticatory system would then lead to painful sensations from the trigeminal region.[59-60] In such cases, the patients experience craniomandibular and cervical spinal pain, and the pain can induce the patients to a new head posture in order to decrease pain. Moya[61] studied the effect of occlusal splints on cranio-cervical relationships in 15 subjects with muscle spasms in the sternocleidomastoid process and trapezius muscles. Cephalometric analysis confirmed that the use of a splint caused a significant extension of the head on the cervical spine. There was also a significant decrease in the cervical spine lordosis in the first, second, and third cervical segments. However, the findings in the current study are the results of cross-sectional evaluations at the time of the diagnosis for the TMD group without regard to the situation of the TMD subjects before the appearance of internal derangement. This is why there are no conclusions regarding possible causes.

Mandibular length (Go-vpUK) was significantly higher in the TMD group than in the control group (Z: 2.870; p<0.01). This result does not agree with those of Dibbets[62] who analyzed lateral skull radiographs of 110 subjects (with TMD) and showed that adults (mean age 26.4, SD 2.6) with signs of clicking were characterized by maxillary and mandibular deficiencies (mandibular length was measured as length of corpus, from gonion to pogonion, and diagonal, from articulare to pogonion). The discrepancy with our results could be explained by our smaller sample. Dibbets[62] did not mention a control group with regard to measuring mandibular and maxillary lengths.

A further finding in the current study was that the mean value of EL was significantly lower in the TMD group than in the control group (Z: 3.771; p<0.001). As illustrated in **Table 3** and **Figure 2**, EL is the projection of mandibular length (from posterior point of condylar head to Pog point) on SN; so EL line (millimetric distance between E Point and L Point) could be influenced by mandibular divergence because of geometrical construction. However, mean value of the GoGn/SN angle was significantly higher in the TMD group than in the control group (Z: 1.997; p<0.05). The combination of these results (differences between the groups with regard to GoGn/SN and EL point) clearly makes the interpretation. Since the variable EL depends, because of its construction, (**Tables 2** and **3**, **Figure 2)**, on the GoGn/SN angle, an increase in the GoGn/SN angle causes geometrically a decrease of the distance between orthogonal projections of pogonion and the posterior point of the condylar head on the SN Line. Also the pogonion and the posterior point of the condylar head are indifferent to mandibular divergence. For this reason, since mandibular length represented by the EL line is geometrically influenced by the GoGn/SN angle, it could be concluded that it is not a convenient method by which to study mandibular dimension.

Mandibular protrusion (SNB angle) was significantly lower in the TMD group than in the control group (Z: 3.720; p<0.001). This was in agreement with previous results[29] which showed lower values of SNB in TMD subjects. However, the mean value of Go-vpUk (which indicates mandibular size and not mandibular position, as indicated by SNB angle) was significantly higher in the TMD group than in the control group (p<0.01). The combination of the results concerning Go-vpUK and SNB in the two groups suggests that TMD subjects show a long mandible (higher Go-vpUK), but more retro-positioned (lower SNB) than control subjects. It could be hypothesized that the retro-position of the jaw could influence the position of the condyle, and perhaps the appearance of internal derangement in the TMJ. But in the current study we cannot affirm that retro-position of the jaw caused the retro-position of the condyle, because we do not know the position of condyle before the occurrence of TMD. Longitudinal studies are required. In this study, the radiologists observed, generally, a more concentric position of condyle-fossa in the control group. This observation was in agreement with Weinberg[63,64] (made with the use of lateral transcranial radiographs and using the method of an assured condylar position in the fossa through millimeter distance between the condylar margin and fossa contour) and with Pullinger[65] (using a tomogram of the condyle and the method of assured condylar position in the fossa through millimeter distance between condylar margin and fossa contour)[66] who observed that a non-concentric condyle-fossa relationship is associated with TMD.

In conclusion, one cannot assume, on the basis of cephalometric relations in cross-sectional studies, that the posterior position of the mandible is responsible for a decrease of the CVT/EVT angle in the test groups. Longitudinal studies would associate a progressive decreasing of CVT/EVT angle with a posterior localization of the mandible. However, these cross-sectional observations are only one reason to improve the research into the neurological and anatomical associations between the cervical column and the morphological aspects of the face.

Although the mean value of the SNA angle was significantly lower in the TMD group than in the control group (Z: 4.007; $p<0.001$), snp-vpOK showed no significant differences between the TMD and the control groups ($p>0.05$). This result suggests that maxillary size does not influence TMJ function. In both groups, variables representing maxillary size (SNA and snp-vpOK) showed significant correlation as expected, ($p<0.01$ in the TMD group; $p<0.001$ in the control group). With regard to mandibular dimensions, mandibular length (Go-vpUK), and position (SNB) did not show a significant correlation. For the maxillary bone we could affirm the opposite concept, that maxillary size and position are closely linked ($p<0.01$ for TMD group; $p<0.001$ for control group). The difference between the SNB angle and snp-vpOK, as representative variables of the maxillary base, is the same that exists between the SNA angle and Go-vpUK for the mandible. In fact, while the SNA angle represents a maxillary position related to the anterior cranial base (SN) and seems to influence the TMJ state, as in Brand[29] snp-vpOk represents the real linear length of the maxillary base, without referring to its position, so its value could not be associated to TMJ status and, as in the current study, to CVT/EVT.

The GoGn/Sn angle showed a highly negative correlation with the CVT/EVT angle in both the TMD and control groups ($p<0.001$ in both groups). The results, although the subjects were taken from a normal angle population as explained in the Material and Methods section, suggest that divergence of the mandible could influence mandibular position and, from this, the CVT/EVT angle. Differences between groups revealed that the mean value of GoGn/SN angle was significantly higher in the TMD group than in the control group (Z: 1.997; $p<0.05$). Also, the mean value of the FM angle (Z: 2.767; $p<0.01$) and MM angle (Z: 2.677; $p<0.01$) were significantly higher in the TMD group than in the control group. Our results agree with those of Stringert and Worms[28] and Nebbe.[30]

Overjet and Overbite

The statistical evidence regarding overbite agreed with the results of Pullinger and Seligman.[67] Many factors acting at the occlusal level have been suggested as having a TMJ orthopedic effect, such as a deep incisal overbite,[65] associated with class II, division II malocclusions,[68-72] although the belief in their role is not universal.[73-74] In our study, overbite was significantly higher in the TMD group than in the control group (Z: 2.210; $p<0.05$). Based on this, our study seems to be in accord with previous findings.[65] Deep bite is commonly said to be a cause of condylar displacement, TMJ joint clicking, joint pain,[75-82] and masticatory muscle tenderness.[83] In other studies, large overbite, usually defined as more than five mm, has been associated with TMJ pain or clicking in TMD adult subjects,[84] usually among orthodontic subjects with symptoms,[85] and with a reduced jaw opening in children and young adults.[86] In contrast, other studies determined no difference in overbite between derangement subjects compared with subjects without derangement,[87] or among adolescents examined for association of large overbite with TMJ signs or symptoms.[88] Pullinger and Seligman[67] concluded that overbite and overjet characteristics as isolated variables did not distinguish TMD patient groups.

Anterior Cranial Base Size

The variable SeN showed a positive correlation with maxillary length (snp-vpOK) in both groups ($p<0.001$). These results are in agreement with Enlow's[89] theory and phylogenetic *package* which basically theorizes that the orientation of the brain seems to influence the spatial relationship of the face. This result confirms the concept that mandibular and maxillary length seem to be influenced by anterior cranial base length.[90] The fact that there was no correlation between the SeN and SNA angles in either group might suggest that, while maxillary length is related to the craniofacial complex, the position of A point related to Sn could depend not only on the real measurement of the maxillary base, but also on the position of S point and N point; so that, the SNA angle does not reflect the real dimension of the maxillary base. An increase in the inclination of the sella-nasion reference line results in the relative posterior positioning of points A, B, and pogonion, in relation to nasion, and values of the angles SNA, SNB, and SNPog decrease topographically.[91-92] This is why we used Schwartz's[51] measurements to describe the morphological correlation between mandibular and cervical dimensions. Another interesting finding of this study is that anterior cranial base length (SeN) did not show significant correlation to the CVT/EVT angle in either group. Correlation was not expected, because of the different developmental process. Finally, no difference between SeN values in the two groups was noted; correlation was not expected, based on the fact that anterior cranial base length probably does not influence the status of the TMJ. However, the absence of this correlation cannot be compared with those of previous studies relative to morphological facial variables in TMD subjects, since those authors did not consider millimeter measurements of the anterior cranial base (SeN).

Limits of the Study

The primary limitation of our investigation is that we did not investigate facial and cervical features of the TMD patients before the appearance of TMD. And because of that, we cannot assume that the displacement of the disk is closely linked to an alteration of cervical lordosis. It is noted that a cross-sectional study can only provide relationships between morphological variables. Longitudinal studies are required to better understand the mechanism at work.

Also, we had to match sample for the quality and the quantity of cervical pain in the TMD subject group and evaluate the cervical lordosis aspect on cephalometrics in the different sub-groups; however, studies on the prevalence of cervical pain in TMD subjects should preferably be performed under blind conditions with regard to the classification of the subjects and by using an objective method to measure pain, such us algometry. This limit hampers the conclusion that the CVT/EVT angle decreasing in TMD patients could cause cervical pain, because we do not know whether in TMD patients without cervical pain there is a decreasing of the CVT/EVT angle. Future studies regarding TMD subjects, whether matched for the quality and the quantity of cervical pain or not, will clarify if progressive cervical pain corresponds to a progressive decrease in the CVT/EVT angle. At the same time, studies on populations matched for different types of TMD will clarify what type of TMD causes cervical pain and an alteration of the cervical lordosis angle.

Conclusion

Possible conclusions of this investigation are:

- In a group of Caucasian adult females, skeletal class II, normal angle, with TMJ disk displacement, an increase of the cervical lordosis angle was associated with an increase of mandibular and maxillary protrusion; with a decrease of mandibular length; with an increase in overjet; with an increase in mandibular divergence; and to a decreased overbite. Conclusions about the how the mechanism works are not possible because of the cross-sectional nature of this study.
- In a group of Caucasian adult females, skeletal class II, normal angle, subjects with TMJ disk displacement showed the following: different morphological facial features (assessed using cephalometrics) compared with a matched control group without TMJ disk displacement; an increased maxillary and mandibular protrusion; an increased mandibular length and a decreased mandibular ramus height; and an increased mandibular divergence.
- In a group of Caucasian adult females, skeletal class II, normal angle, with TMJ disk displacement, cervical posture of the upper and the lower segment of the cervical spine did not show important clinical differences in cervical posture when compared with a matched control group without TMJ disk displacement. However, the cervical lordosis angle was significantly lower in the study group than in the control group.

References

1. Solow B, Barrett MJ, Brown T: Craniocervical morphology and posture in Australian Aboriginals. *Am J Phys Anthrop* 1982; 59:33-45.
2. Kylämarkula S, Huggare JÅV: Morphology of the first cervical vertebra in children with enlarged adenoids. *Eur J Orthod* 1985; 7:93-96.
3. Kylämarkula S, Huggare JÅV: Head posture and the morphology of the first cervical vertebra. *Eur J Orthod* 1985; 7:151-156.
4. Huggare JÅV: The first cervical vertebrae as an indicator of mandibular growth. E*ur J Orthod* 1989; 11:10-16.
5. Huggare JÅV: Association between morphology of the first cervical vertebra, head posture, and craniofacial structures. *Eur J Orthod* 1991; 13:435-440.
6. Huggare JÅV, Cooke MS: Head posture and cervicovertebral anatomy as mandibular growth predictors. *Eur J Orthod* 1994; 16:175-180.
7. Sandikçioglu M, Skov S, Solow B: Atlas morphology in relation to craniofacial morphology and head posture. *Eur J Orthod* 1994; 16:96-103.
8. Huggare JÅV, Houghton P: Association between atlantoaxial and craniomandibular anatomy. *Growth Dev Aging* 1996; 60:21-30.
9. Grave B, Brown T, Townsend G: Comparison of cervicovertebral dimensions in Australian Aborigines and Caucasians. *Eur J Orthod* 1999: 21:127-135.
10. Solow B, Tallgren A: Natural head position in standing subjects. *Acta Odont Scand* 1971; 29:591-607.
11. Solow B, Tallgren A: Head posture and craniofacial morphology. *Am J Phys Anthropol* 1976; 44:417-436.
12. Marcotte MR: Head posture and dentofacial proportions. *Angle Orthod* 1981; 51:208-213.
13. Solow B, Siersbæk-Nielsen S, Greve E: Airway adequacy, head posture and craniofacial morphology. *Am J Orthod* 1984; 86:214-223.
14. Solow B, Siersbæk-Nielsen S: Growth changes in head posture related to craniofacial development. *Am J Orthod* 1986; 89:505-507.
15. Hellsing E, Reigo T, McWilliam J, Spangfort E: Cervical and lumbar lordosis and thoracic kyphosis in 8, 11 and 15-year-old children. *Eur J Orthod* 1987; 9:129-138.
16. Hellsing E, McWilliam J, Reigo T, Spangfort E: The relationship between craniofacial morphology, head posture and spinal curvature in 8, 11, and 15-year-old children. *Eur J Orthod* 1987; 9:254-264.
17. Showfety KJ, Vig PS, Matteson S, Phillips C: Associations between the postthodural orientation of sella-nasion and skeletodental morphology. *Angle Orthod* 1987; 57:99-112.
18. Cooke MS, Wei SHY: Intersex differences in craniocervical morphology and posture in southern Chinese and British Caucasians. *Am J Phys Anthropol* 1988; 77:43-51.
19. Huggare JÅV, Raustia A: Head posture and cervicovertebral and craniofacial morphology in patients with craniomandibular dysfunction. *J Craniomandib Pract* 1992; 13:435-440.
20. Solow B, Siersbæk-Nielsen S: Cervical and craniocervical posture as predictors of craniofacial growth. *Am J Orthod Dentofac Orthop* 1992; 101:449-458.
21. Özbek MM, Köklü A: Natural cervical inclination and craniofacial structure.

Am J Orthod Dentofac Orthop 1993; 104:584-591.
22. Huggare JÅV, Tellervo Laine-Alava M: Nasorespiratory function and head posture. *Am J Orthod Dentofac Orthop* 1997; 112:507-511.
23. Bench RW: Growth of the cervical vertebrae as related to tongue, face, and denture behavior. *Am J Orthod* 1963; 49:183-214.
24. Linder-Aronson S: Adenoids: their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the dentition. *Acta Otolaryngol* (Stockh) 1970; [Suppl]:265.
25. Linder-Aronson S: Effects of adenoidectomy on dentition and nasopharynx. *Am J Orthod* 1974; 65:1-15.
26. Carlsöö S, Leijon G: A radiographic study of the position of the hyo-laryngeal complex in relation to the skull and the cervical column in man. *Stockholm and Umeå: Transactions of the Royal Schools of Dentistry* 1960; 5:13-34.
27. Miralles R, Moya H, Ravera MJ, Santander H, Zuniga C, Carvajal R, Yazigi C: Increase of the vertical occlusal dimension by means of a removable orthodontic appliance and its effect on craniocervical relationships and position of the cervical spine in children. *J Craniomandib Pract* 1997; 15(3):221-228.
28. Stringert HG, Worms FW: Variations in skeletal and dental patterns in patients with structural and functional alterations of the temporomandibular joint: a preliminary report. *Am J Orthod* 1986; 89:285-297.
29. Brand JW, Nielson KJ, Tallents RH, Nanda RS, Currier GF, Owen WL: Lateral cephalometric analysis of skeletal patterns in patients with and without internal derangement of the temporomandibular joint. *Am J Orthod Dentofac Orthop* 1995; 107:121-128.
30. Nebbe B, Major PW, Prasad NG, Grace M, Kamelchuk LS: TMJ internal derangement and adolescent craniofacial morphology: a pilot study. *Angle Orthod* 1997; 6:407-414.
31. Bosio JA, Burch JG, Ross HT, Wade DB, Beck FM: Lateral cephalometric analysis of asymptomatic volunteers and symptomatic patients with or without bilateral temporomandibular joint disk displacement. *Am J Orthod Dentofac Orthop* 1998; 114:248-255.
32. McRae DL: The significance of abnormalities of the cervical spine. *Am J Roentgen Rad Ther Nucl Med* 1960; 84:3-25.
33. Kantor ML, Norton LA: Normal radiographic anatomy and common anomalies seen in cephalometric films. *Am J Orthod Dentofac Orthop* 1987; 91:414-426.
34. Clark GT, Green EM, Dornan MR, Flack VF: Craniocervical dysfunction levels in a patient sample from a temporomandibular joint clinic. *JADA* 1987; 115:251-256.
35. Cacchiotti DA, Plesh O, Bianchi P, McNeill C: Signs and symptoms in samples with and without temporomandibular disorders. *J Craniomandib Disord Fac Oral Pain* 1991; 5:167-172.
36. De Laat A, Meuleman H, Stevens A, Verbeke G: Correlation between cervical spine and temporomandibular disorders. *Clin Oral Invest* 1998; 2:54-57.
37. Ciancaglini R, Testa M, Radaelli G: Association of neck pain with symptoms of temporomandibular dysfunction in the general adult population. *Scand J Rehab Med* 1999; 31:17-22.
38. Hensinger RN. Congenital anomalies of the cervical spine. *Clin Orthop* 1991; 264:16-38.
39. Vastardis H, Evans CA: Evaluation of cervical spine abnormalities on cephalometric radiographs. *Am J Orthod Dentofac Orthop* 1996; 109:581-588.
40. Steiner CC: Cephalometric for you and me. *Am J Orthod* 1953; 39:729-755.
41. Visscher CM, Lobbezoo F, De Boer W, Van Der Zaag J, Verheij JGC, Naeije M: Clinical tests in distinguishing between persons with or without craniomandibular or cervical spinal pain complaints. *Eur J Oral Sci* 2000; 108:475-483.
42. Tasaki MM: *Magnetic resonance imaging and arthrographic assessment of temporomandibular joint disk displacements* [Thesis]. Umeå, Sweden: University of Umeå, 1993.
43. Tasaki MM, Westesson P-L, Isberg AM, Ren Y-F, Tallents RH: Classification and prevalence of temporomandibular joint disk displacement in patients and symptom-free volunteers. *Am J Orthod Dentofac Orthop* 1996; 109:249-262.
44. Katzberg RW, Dolwick MF, Bales DS, Helms CA: Arthroscopy of the temporomandibular joint: new technique and preliminary observations. *Am J Roentgen* 1979; 132:949-955.
45. Mølhave A: *En biostatisk undersøgelse* [Thesis]. Copenhagen: Munksgaard, 1958.
46. Solow B, Tallgren A: Postural changes in craniocervical relationships. *Tandlaegebladet* 1971; 75(12):1247-1257.
47. Broadbent BH Sr, Broadbent BH Jr, Golden WH: *Bolton standards of dentofacial developmental growth*. St. Louis: CV Mosby, 1975:85-87.
48. Meschan I: *Synopsis of analysis of roentgen signs in general radiology*. Philadelphia: Saunders, 1978:189.
49. Salzmann JA: *Roentgenographic cephalometrics: atlas of norm*. Philadelphia: Lippincott, 1961; 29-30,130.
50. Snell RS, Wyman AC: *An al radiographic anatomy*. Boston: Little, Brown, 1976; 275.
51. Rakosi T, Irmtrud J: *Diagnostica ortognatodontica*. Milano: Masson Ed. It. Nidoli G, 1993; 186.
52. Dahlberg G: *Statistical methods for medical and biological students*. London: George Allen and Unwin Ltd, 1940.
53 . Helwig JT, Council KA, eds.: *SAS user's guide*. Raleigh, NC, SAS Institute, Inc, 1979.
54. Kleinbaum DG, Kupper LL, Mulle KE: *Applied regression analysis and other multivariable methods*. 2nd ed. Boston: PWS-KENT Publishing Company, 1988.
55. Glanz SA: *Primer of biostatistics*. New York: McGraw-Hill Inc, 1997.
56. Al-Abbasi H, Mehta NR, Forgione AG, Clark RE: The effect of vertical dimension and mandibular position on isometric strength of cervical flexors. *J Craniomandib Pract* 1999; 17(2):85-92.
57. Dworkin SF, LeResche L: Research diagnostic criteria for temporomandibular disorders. Review, criteria, examinations and specifications, critique. *J Craniomandib Disord Facial Oral Pain* 1992; 6:301-355.
58. Kight M, Gatchel RJ, Wesley L: Temporomandibular disorders: evidence for significant overlap with psychopathology. *Health Psychol* 1999; 18:177-182.
59. Sessle BJ, Hu JW, Amano N, Zhong G: Convergence of cutaneous, tooth pulp, visceral, neck and muscle afferents onto nociceptive and non-nociceptive neurons in trigeminal sub-nucleus caudalis (medullary dorsal horn) and its implications for referred pain. *Pain* 1986; 27:219-235.
60. Coderre TJ, Katz J, Vaccarino AL, Melzack R: Contribution of central neuroplasticity to pathological pain: review of clinical and experimental evidence. *Pain* 1993; 52:259-285.
61. Moya H, Miralles R, Zuniga C, Carvajal R, Rocabado M, Santander H: Influence of stabilization occlusal splint on cranio-cervical relationships. Part I: cephalometric analysis. *J Craniomandib Pract* 1994; 12(1):47-51.
62. Dibbets JMH: Signs and symptoms of temporomandibular disorder (TMD) and craniofacial form. *Am J Orthod Dentofac Orthop* 1996; 110:73-78.
63. Weinberg LA: Practical evaluation of the lateral temporomandibular joint radiograph. *J Prosthet Dent* 1984; 51:676-685.
64. Weinberg LA: An evaluation of occlusal factors in TMJ dysfunction-pain syndrome. *J Prosthet Dent* 1979; 41:198-208.
65. Pullinger AG, Solberg WK, Hollender L, Petersson A: Relationship of mandibular condylar position to dental occlusion factors in an asymptomatic population. *Am J Orthod Dentofac Orthop* 1987; 91:200-206.
66. Pullinger AG, Hollender L, Solberg WK, Petersson A: A tomographic study of mandibular condyle position in an asymptomatic population. *J Prosthet Dent* 1985; 53:706-713.
67 Pullinger AG, Seligman DA: Overbite and overjet characteristics of refined diagnostic groups of temporomandibular disorder patients. *Am J Orthod Dentofac Orthop* 1991; 100:401-415.
68. Perry HT: Relation of occlusion to temporomandibular dysfunction: the orthodontic viewpoint. *JADA* 1969; 79(1):137-141.
69. Loiselle RJ: Relation of occlusion to temporomandibular joint dysfunction: the prosthodontic viewpoint. *JADA* 1969; 79(1):145-146.
70. Greene CS: A survey of current professional concepts and opinions about the myofascial pain dysfunction (MPD) syndrome. *JADA* 1973; 86:128-135.
71. Rey R, Barghi N, Bailey JO: Correlation between Angle's occlusion and mandibular dysfunction [Abstract 930]. *J Dent Res* 1981; 60:542.
72. Solberg WK, Seligman DA: Temporomandibular orthopedics: a new vista in orthodontics. In: Johnston LA Jr, ed. *New vistas in orthodontics*. Philadelphia: Lea & Febiger, 1985;148-183.
73. Mohlin B, Kopp S: A clinical study on the relationship between malocclusions, occlusal interferences and mandibular pain and dysfunction. *Swed Dent* 1978; 2:105-112.
74. Pullinger AG, Seligman DA, Solberg WK: Temporomandibular disorders. Part II. Occlusal factors associated with temporomandibular joint tenderness and dysfunction. *J Prosthet Dent* 1988; 59:363-367.
75. Ricketts RM: Abnormal function of the temporomandibular joint. *Am J Orthod* 1955; 41:435-441.
76. Owens AH: Orthodontic/orthopedic treatment of craniomandibular pain dysfunction. Part 2. Posterior condylar displacement. *J Craniomandib Pract* 1984; 2:334-349.
77. Ireland VE: The problem of "the clicking jaw". *J Prosthet Dent* 1953; 3:200-212.
78. Gerber A: *Kiefergelenk und Zahnokklusion*. Dtsch Zahnarztl Z 1971; 26:119-141. (English translation, Condylator Service, Zurich.)
79. Berry DC, Watkinson AC: Mandibular dysfunction and incisor relationship: a theoretical explanation for the clicking joint. *Br Dent J* 1978; 144:74-77.
80. Bell WE: *Clinical management of temporomandibular disorders*. Chicago: Year Book Medical, 1982; 71-74.
81. Heloe B, Heiberg AN, Krogstad BS: A multiprofessional study of patients

with myofascial pain dysfunction syndrome. I. *Acta Odontol Scand* 1980; 38:1-9.
82. Lieberman M, Gazit E, Fuchs C, Lilos P: Mandibular dysfunction in 10-18 year old school children as related to morphological occlusion. *J Oral Rehabil* 1985; 12:209-214.
83. Seligman DA, Pullinger AG, Solberg WK: Temporomandibular disorders. Part III. Occlusal and articular factors associated with muscle tenderness. *J Prosthet Dent* 1988; 59:483-489.
84. Williamson EH: Temporomandibular dysfunction in pretreatment adolescent patients. *Am J Orthod* 1977; 72:429-433.
85. Williamson EH: On occlusion and TMJ dysfunction. Part I. *J Clin Orthod* 1981; 15:333-350.
86. Riolo ML, Brandt D, TenHave TR: Associations between occlusal characteristics and signs and symptoms of TMJ dysfunction in children and young adults. *Am J Orthod Dentofac Orthop* 1987; 92:467-477.
87. Roberts CA, Tallents RH, Katzberg RW, Sanchez-Woodworth RE, Espeland MA, Handelman SL: Comparison of internal derangements of the TMJ with occlusal findings. *Oral Surg Oral Med Oral Pathol* 1987; 63:645-650.
88. Kampe T, Carlsson GE, Hennerz H, Haraldson T: Three year longitudinal study of mandibular dysfunction in young adults with intact and restored dentitions. *Acta Odontol Scand* 1987; 45:25-30.
89. Enlow DH: *Handbook of facial growth*. Philadelphia: WB Saunders Co., 1982.
90. Hilloowala RA, Trent RB, Pifer RG: Interrelationships of brain, cranial base and mandible. *J Craniomandib Pract* 1998; 16(4):267-274.
91. Wei SHY: The variability of roentgenographic cephalometric lines of reference. *Angle Orthod* 1968; 38:74-78.
92. Lundstrom A: Head posture in relation to slope of the sella-nasion line. *Angle Orthod* 1982; 52:79-82.

Dr. Marco Dolci *received his M.D. degree in 1989 from the University of Rome, and a specialty in maxillofacial surgery in 1994 from the University of Verona. He has been a researcher at the same university since 1996. Dr. Dolci is an associate professor at the University of Chieti and a member of the Italian Association of Maxillofacial Surgery. He has authored many clinical and research articles.*

Dr. Ettore Epifania *is currently an associate professor at the University of Napoli. Dr. Epifania has written many clinical and research articles.*

Dr. Fabio Ciuffolo *received his D.D.S. degree in 2001 from the Faculty of Dentistry, University of Chieti, Italy. Since 2001, he has been an assistant at the Department of Gnathology and Orthodontics at the same university. He attends a fellowship in oral pathology prevention.*

Dr. Vincenzo Salini *received his M.D. degree in 1999 from the Faculty of Medicine, University of Chieti, Italy and a degrees in orthopedics and sporting medicine in 1996 and 2000, respectively. Dr. Salini is a orthopedic doctor in the Orthopedic Division at the Hospital of Chieti, Italy.*

Dr. Maria Rita Filippi *received her D.D.S. degree in 1992 from the Faculty of Dentistry, University D'Annunzio, Chieti, Italy. She is currently an assistant in the Department of Orthodontics and Gnathology at the same university.*

Dr. Felice Festa *is Director of the Department of Orthodontics and Gnathology, School of Dentistry and a professor of orthodontics at the University of Chieti, Italy. He is also Director of the Post Graduate Courses in Clinical Gnathology and Orthodontics at the same university. He received his M.D. degree from the University of Rome in 1979, a D.D.S. degree from the University of Rome in 1982, and earned an M.S. in orthodontics in 1985 from the University of Cagliari. In 2001, he was nominated National Referee Professor in Orthodontics at the Professor National College. Dr. Festa has authored many clinical and research articles and is a former reviewer for* ***CRANIO****: The Journal of Craniomandibular Practice.*

Dr. Simona Tecco *received her D.D.S. degree in 1999 from the Faculty of Dentistry, University of Chieti, Italy. Since then she has been an assistant in the Department of Orthodontics and Gnathology at the same university. Dr. Tecco is attending a fellowship in oral pathology prevention.*