Original Article

Head Posture and Lower Arch Dental Crowding

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ABSTRACT

Objective: To test the null hypothesis that there is no relationship between the posture of the head and the neck and late lower arch crowding.

Materials and Methods: The sample comprised 55 subjects (23 female, 32 male), age 12–18 years, with complete permanent dentition and without previous orthodontic treatment. Space conditions were valued by Nance's space analysis on the study models. Craniovertical, craniocervical, and craniohorizontal postural variables were recorded from lateral cephalograms. Student's *t*-test was performed to assess the differences of the postural angles between the two groups.

Results: The results showed that the differences of the postural variables between the two groups are statistically significant. Subjects with more than 2 mm dental crowding had mean craniocervical angles (NSL/CVT, NSL/OPT, NL/CVT, NL/OPT) that were 5° to 6° larger than the subjects with the space conditions smaller than 2 mm ($P \leq .01$). In addition, the mean craniohorizontal angles (CVT/Hor, OPT/Hor) in the subjects with lower dental crowding were 4° smaller than subjects without dental crowding ($P < .05$).

Conclusions: The hypothesis is rejected. A clear pattern of association between extended head posture and lower arch dental crowding was found. (*Angle Orthod.* 2009;79:873–879.)

KEY WORDS: Head posture; Crowding

INTRODUCTION

The head and cervical traits of the vertebral column are part of a functional biomechanical unit, the cranial cervical mandibular system. This system is made up of three main structures: TMJ, occipital atlas axis articulation, and hyoid bone with its suspensor system. These three structures are strictly interdependent, but joined together with the rest of the body (vertebral column) by muscles and ligaments. Consequently, it is not unreasonable to expect that cervical posture can be related to craniofacial morphology[1–6] and nasorespiratory function.[7–11]

According to Solow and Tallgren,[1] extended craniocervical posture is frequently associated with an increase of anterior facial height, a decrease of sagittal jaw dimensions, and a steeper inclination of the mandible. When the head is flexed (in relation to the cervical column), anterior facial height is shorter, sagittal jaw dimensions are larger, and the mandibular plane is flatter.

Marcotte[2] also reported a significant correlation between mandibular position and head posture: people with a hollow facial profile showed a tendency to bend the head downward, while people with a convex profile showed a tendency to bend the head upward.

An association between Class II malocclusion and forward head posture (or forward cervical inclination combined with an extended craniocervical angle) was described by Rocabado et al[3] as the stronger evidence they had observed in the relationship between head posture and malocclusion. Similar results were obtained by Capruso et al[4] who showed that forward head posture was associated with a very high probability of skeletal Class II and hyperdivergency.

D'Attilio et al[5] found that the lower part of the spinal column was significantly straighter in subjects in skeletal Class III than in subjects in skeletal Class I and skeletal Class II. They stated that the size and position of the mandible are two factors that are strongly related to cervical posture. Based on all of these results, it is reasonable that head posture should be considered an important element of orthodontic diagnosis.

In the literature, a rarely discussed aspect is the possible relationship between dental crowding and the

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posture of the head and the neck. Dental crowding can be described either as a dentoalveolar discrepancy between available space (the space offered by bone to distribute all of the teeth) and the space needed (the space that is equivalent to the mesial distal width of all of the teeth),[12] or as lack of a correct dental alignment with anomalous dental inclination, position, or rotation.[13] This occlusal condition has a multifactorial etiology and shows a wide incidence after eruption of the second permanent molar.[14–21]

AlKofide and AlNamankani[22] examined whether a relationship exists between posture of the head and neck, and the presence of certain malocclusions. In their study, a relationship between crowding and head posture could only be found in subjects with upper arch crowding and cervical curvature and not with lower dental crowding.

In a previous study, Solow and Sonnesen[6] showed a strong inverse correlation between internal craniocervical angles and dental crowding greater than 2 mm. In particular, subjects with dental crowding of more than 2 mm in the lower anterior segment of the dental arch had mean craniocervical angles 3° to 5° larger than subjects without crowding.

The aim of the present investigation is to test if any relationships could be found between head posture and late lower arch crowding.

MATERIALS AND METHODS

For this study, we analyzed the pretreatment records of 200 randomly selected patients treated in the Department of Orthodontics, University of Rome, Tor Vergata. One hundred forty-five subjects were not included in the sample because they did not satisfy the inclusion criteria. Fifty-five subjects (27 female, 28 male; 12–18 years of age) were selected on the basis of the following inclusion criteria:

- Complete permanent dentition (without taking into consideration the eruption state of the third molar);
- No previous orthodontic treatment;
- No TMJ or cervical spine disorders.

Study Models

All selected subjects were divided into two groups based on lower arch dental crowding as determined by Nance's space analysis.[12] The necessary space has been calculated as the sum of the mesiodistal width of all teeth between the mesial contact points of the left and right second molar. These widths have been measured by a caliper positioned parallel to the long axis of the tooth.

The available space, or real arch perimeter, has been calculated as the length of a brass wire modeled in relation to the individual shape of the lower arch, using the incisor margins and buccal cusps of the posterior teeth.

Space conditions have been calculated as the difference between available space and necessary space. Negative values showed a lack of space (crowding), while positive values (or value $= 0$) showed a well-aligned arch or excess of space in the arch to align correctly all teeth.

The 55 subjects were divided into two groups on the basis of Solow and Sonnesen's study.[6] This resulted in a study group made up of 28 subjects (14 female and 14 male; average age 15 years) with dental crowding larger than 2 mm and a control group made up of 27 subjects (14 female and 13 male; average age 14.7 years) with dental crowding smaller or equal to 2 mm. This division was made to verify if subjects of the study group showed a different head posture compared with the subjects with good space conditions.

Lateral Cephalometric Radiographs

Teleradiographs were made before beginning the study. Lateral skull radiographs were taken using Proline Ceph CM (Planmeca). The x-ray source had a focus of 0.6 mm, and the exposure data were 72 kV and 32 mA for 1.2 seconds. The equipment had a fixed film to focus plane distance of 190 cm and a fixed film to midsagittal plane distance of 10 cm with a final enlargement of 10%. For all subjects, 24×30 cm films were used. All lateral skull radiographs were taken by the same operator with the subjects standing in orthoposition with the head in the natural head position (self-balanced position) as described by Sahin Sağlam and Uydas.[23] The lateral radiographs had to include the first four cervical vertebrae.

The lateral cephalograms were traced on acetate paper. Seven reference points (Table 1 and Figure 1) were marked on acetate papers including four points in the craniofacial area and three points in the cervical column area. Six lines (Table 2 and Figure 1) were considered. The eight variables studied are listed in Table 3. The cervical reference line and the postural variables were traced according to Solow and Tallgren.[24]

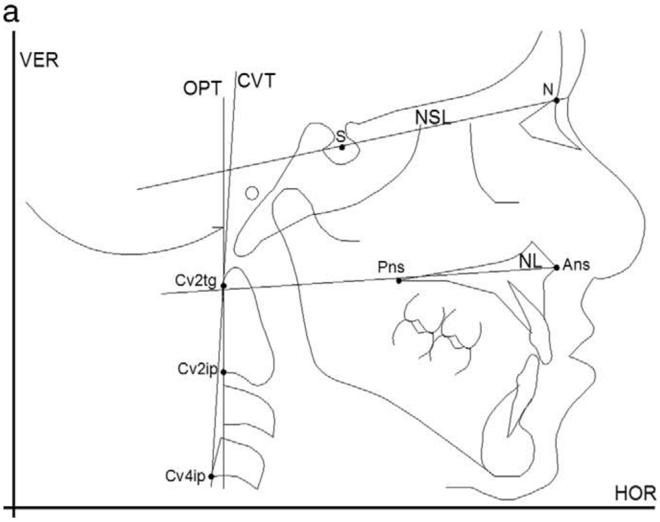
Error of Measurements

All measurements on the models and radiographs were made twice by the same operator to minimize the error of measurements. The same measurements were undertaken 2 weeks later, and no significant differences were found for any variables in the two data groups (paired *t*-test). The measurement error was calculated using 20 radiographs (10 randomly chosen

Table 1. Reference Points of the Cephalograms

Cephalometric Reference Point	Description	Characterization of Reference Point
S	Sella turcica	The midpoint of sella turcica
N	Nasion	The intersection of the internasal suture with nasofrontal suture in the midsagittal plane
Ans	Anterior nasal spine	Tip of the anterior nasal spine seen on the x-ray from the normal lateralis
Pns	Posterior nasal spine	Tip of the posterior spine of the palatine bone in the hard palate
Cv2tg		Tangent point of OPT line on the odontoid process of the second cervical vertebra
Cv2ip		The most inferior posterior point on the corpus of the second cervical vertebra
Cv4ip		The most inferior posterior point on the corpus of the fourth cervical vertebra

a



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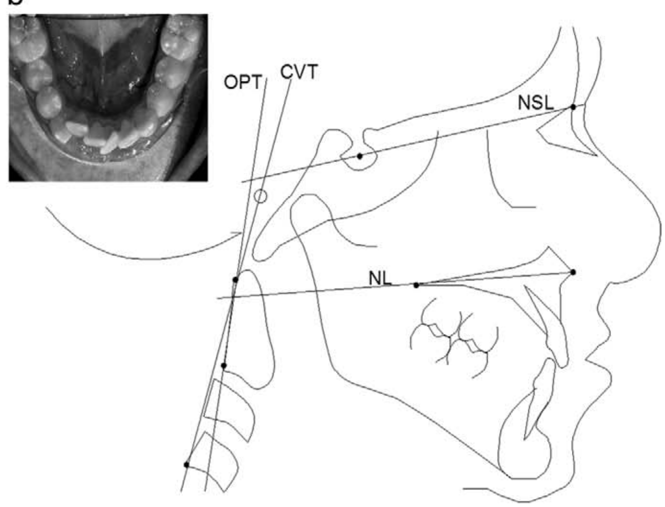

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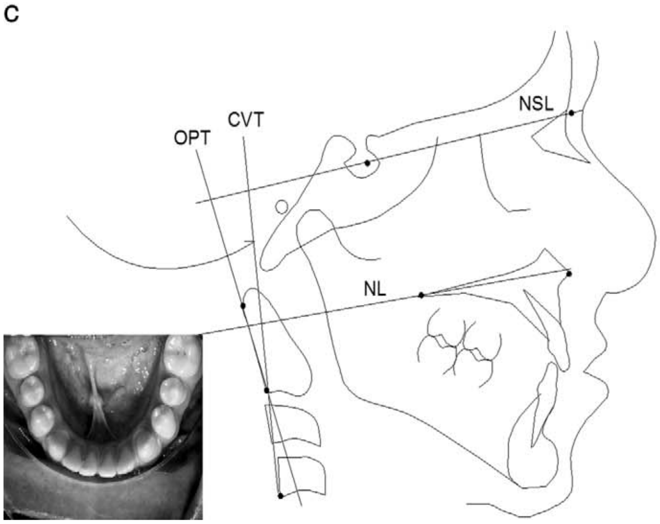

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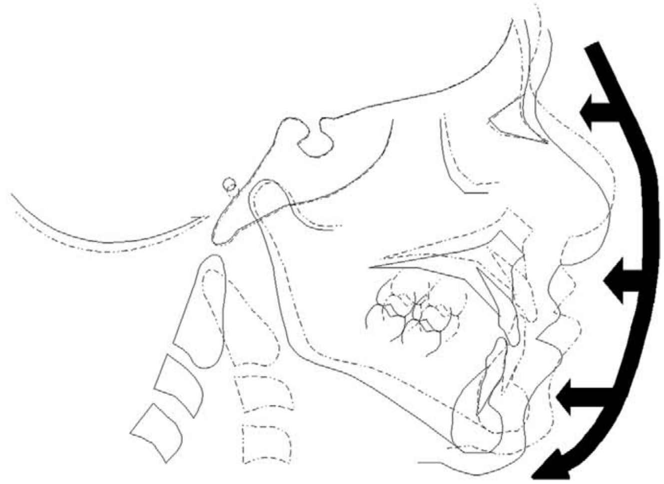

Figure 1. Reference points and cephalometric tracings used in the study.

Figure 2. Lateral cephalograms and lower arch crowding in subjects with extended craniocervical posture.

Figure 3. Lateral cephalograms and lower arch with a good alignment in a subject with flexed craniocervical posture.

Figure 4. Lateral cephalograms superimposed on horizontally oriented nasion sella line. The soft tissue stretching creates a pressure increase directed dorsally and caudally against teeth and skeleton passing by a flexed posture (– – –) to extended posture (——) (Solow and Kreiborg[26]).

Table 2. Reference Lines of the Cephalograms

Cephalometric Reference Line	Description	Characterization of Reference Point
Ver	True vertical line	True vertical line projected on the film
Hor	True horizontal line	True horizontal line projected on the film
NSL	Cranial base	Line extending between sella and nasion
NL	Palatal plane	Line extending between Ans and Pns
CVT	Cervical vertebra tangent	Posterior tangent to the odontoid process through Cv4ip
OPT	Odontoid process tangent	Posterior tangent to the odontoid process through Cv2ip

from the group with lower dental crowding and 10 from the group without lower dental crowding) and Dahlberg's formula. The error varied from 0.50° (CVT/Hor) to 0.90° (NSL/Ver) with a mean of 0.68°.

Statistical Analysis

Data were analyzed using SPSS for Windows version 1.3. The postural variables were calculated as the mean and standard deviation. The Student's *t*-test was used to determine if significant postural difference existed between the two groups. Statistical significance was set at $P < .01$ and $P < .05$.

RESULTS

The 28 subjects of the study group showed a mean dental crowding of −3.85 mm (DS = 1.60), while the 27 subjects of the control group showed a mean excess space of 1.09 mm (DS = 2.2). Means and standard deviations of the craniovertical, craniocervical, and craniohorizontal angles are shown in Table 4.

The *t*-test showed differences of postural variables between the two groups (Table 4). The subjects with more than 2 mm of dental crowding had mean craniocervical angles that were 5° to 6° larger than the mean angles of subjects with space conditions smaller than 2 mm ($P < .01$). Furthermore, the means of the craniohorizontal angles in the study group were 3.5° to 4° smaller than those in the control group ($P < .05$). For the other angles, no statistically significant difference was found ($P \leq .1$).

DISCUSSION

The present study shows a clear pattern of association between more than 2 mm of lower arch crowding (left to right first molar included) and extended craniocervical posture (expressed by an increase of NSL/CVT [$P = .002$], NSL/OPT [$P = .001$], NL/CVT [$P = .008$], and NL/OPT [$P = .002$]) as the Solow and Sonnesen's[6] results (Figures 2 and 3).

How can head posture be associated with lower arch malalignment? We can only hypothesize about this relationship. According to Proffit's equilibrium theory,[25] the teeth and facial skeleton are submitted constantly to the action of "external" lip and cheek forces and to "internal" tongue forces, and these pressures influence tooth position and facial morphology. This influence depends more on the duration of application time than on the intensity of the forces: a light force that acts for a long time on the jaw can induce more modifications than a strong force that acts for a short time. Proffit[25] stated that in dental skeleton modifications, a very important rule is played by "a long-term muscular activity: the resting pressure of the lips, cheeks, and tongue."

The soft perioral tissue stretching hypothesis formulated by Solow and Kreiborg[26] can explain how the resting muscular activity depends on the head posture in relation to the vertebral column. According to this hypothesis, the soft tissue layer (skin, muscles, and fascia) that covers the head and neck, stretches and relaxes itself in relation to the degree of extension or flexion of the head. In cases of long-term hyperextension of the head posture, these soft tissues stretch, creating a dorsal and caudal force against the teeth and skeleton (Figure 4). If this force is not balanced by an increase of tongue muscular activity, it can induce a dorsal and caudal restraint on facial development and a retroinclination of the incisors with a consequent loss of correct alignment. Normal head posture can induce relaxed soft tissues with consequent sagittal development and proclination of the incisors.

The association between head posture and lower arch crowding could also explain the reports of Linder-Aronson[27] and Woodside et al.[28] They showed that subjects with obstruction of the nasopharyngeal airway presented a greater irregularity index and reduced incisor inclinations relative to the subjects without nasal airway obstruction. Furthermore, they showed that after adenoidectomy, and with the return of nasal respiration, an increased inclination of the incisors resulted.

A reduction of the nasal airway can cause, by reflex, a hyperextension of the head to facilitate air passage. An increase of the craniocervical angles is demonstrated in children with adenoids,[7] with enlarged tonsils,[8] with nasal allergy,[9] and in patients with obstructive sleep apnea.[10]

Table 3. List of Variables

Cephalometric Variable	Description	Characterization of Reference Points
Craniofacial posture (craniovertical angles)		
NSL/Ver	Anterior cranial base inclination	Downward opening angle between NSL line and Ver line
NL/Ver	Palatal line inclination	Downward opening angle between NL line and Ver line
Craniocervical angulations		
NSL/OPT	Craniocervical posture	Downward opening angles between NSL line and OPT line
NSL/CVT		Downward opening angles between NSL line and CVT line
NL/OPT	Maxillary base inclination upon cervical column	Downward opening angles between NL line and OPT line
NL/CVT		Downward opening angles between NL line and CVT line
Cervical posture		
CVT/Hor	Craniohorizontal angle	Upward opening angles between Hor line and CVT line
OPT/Hor		Upward opening angles between Hor line and OPT line

The experiment of Vig et al[11] demonstrated that when the nasal airway is obstructed, internal craniocervical angles immediately increased 5°. The head rotated behind and the jaw turned down. When the obstruction was removed, the head returned to its normal position. In order to consider the soft tissue stretching theory a valid determinant of the association between dental crowding and head posture, it is important that the stretch determine a real dorsally directed force that can alter the equilibrium between the lips, cheeks, and tongue on the incisors. Many studies have reported the lip pressure on the incisors in rest conditions. Parfitt[29] recorded a lip pressure on the incisors between 3 g/cm^2 and 5 g/cm^2, while Winders[30] reported this pressure was 6 g/cm^2. Also, Thuer et al[31] recorded lip pressure both on the upper and lower incisors and found large individual variation with mean values of 2.2 g/cm^2 for the upper incisors and 9.4 g/cm^2 for the lower incisors.

Hellsing and L'Estrange[32] measured these pressures in relation to head posture on 15 adult subjects with normal respiration. In conditions of normal head posture, the lip pressures were 3.5 g/cm^2 on the upper incisors and 8.5 g/cm^2 on the lower incisors according to the result of Thuer et al.[31] During head extension, a significant increase of the lip pressure both on the upper incisors (between 0.8 g/cm^2 and 1.4 g/cm^2) and on the lower incisors (between 1.17 g/cm^2 and 1.95 g/cm^2) was recorded. However, during head flexion the lip pressure decreased progressively.

Even though the lip pressure on the lower incisors

Table 4. Mean, Standard Deviation, and Mean Difference of the Postural Variables in Subjects With and Without Dental Crowding[a]

Variable (degree)	Crowding	Mean	Standard Deviation	Mean Difference
NSL/Ver	No	99.33	4.85	2.27*
	Yes	101.61	4.76	
NSL/OPT	No	98.74	4.31	6.37***
	Yes	105.11	8.56	
NSL/CVT	No	103.30	4.67	6.03***
	Yes	109.32	8.58	
OPT/Hor	No	90.59	4.82	−4.09**
	Yes	86.50	6.48	
CVT/Hor	No	86.04	4.29	−3.75**
	Yes	82.29	6.75	
NL/Ver	No	91.19	6.10	1.60*
	Yes	92.79	5.57	
NL/OPT	No	90.59	4.85	5.69***
	Yes	96.29	7.75	
NL/CVT	No	95.15	5.14	5.35***
	Yes	100.50	8.80	

[a] Total sample size: 55 subjects. Dental crowding sample size: 28 subjects. No dental crowding sample size: 27 subjects.

* $P \leq .1$; ** $P < .05$; *** $P < .01$.

increases in cases of extended craniocervical posture, in order to the equilibrium theory[25] it is important to consider if a correlation exists between an increased the craniocervical angle and tongue forces. In 1981, Wood[33] studied subjects with Class I occlusion and recorded the pressures of the anterior and posterior part of the tongue on the lower arch. When the subjects assumed a hyperextension of the head, the pressure decreased at the anterior part of the tongue.

In addition, Archer and Vig[34] studied the modifications of anterior and posterior lingual pressures in relation to the head posture in 10 adult subjects with Class I malocclusion. They showed that the anterior lingual pressure on the lower arch decreased significantly when the subjects moved from a flexed to an extended head position.

All of these findings show that in cases of extended craniocervical posture, the equilibrium between lips, cheeks, and tongue on the lower incisors is altered. In fact, extended head posture creates a stretch of the oral soft tissues resulting in increased lip pressure and in decreased pressure of the anterior part of the tongue on the lower incisors. This ''long-term'' condition could modify the inclination of the lower incisors toward a lingual direction. In our opinion, it could be useful to improve this study by increasing the size of the sample group and by evaluating if a difference in inclination of incisors exists between patients with extended and flexed head posture.

CONCLUSIONS

- There is a statistically significant association between an increase of craniocervical angles and lower arch dental crowding.
- Thus, the head posture is another factor that could affect the occurrence of the dental crowding, an occlusal condition with a multifactorial etiology.

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