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 $5^\circ$ to $6^\circ$ larger than the subjects with the space conditions smaller than 2 mm ($P < .01$). In addition, the mean craniohorizontal angles (CVT/Hor, OPT/Hor) in the subjects with lower dental crowding were $4^\circ$ 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 and nasorespiratory function.

According to Solow and Tallgren, 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 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 as the stronger evidence they had observed in the relationship between head posture and malocclusion. Similar results were obtained by Capruso et al who showed that forward head posture was associated with a very high probability of skeletal Class II and hyperdivergency.

D’Attilio et al 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
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), or as lack of a correct dental alignment with anomalous dental inclination, position, or rotation. This occlusal condition has a multifactorial etiology and shows a wide incidence after eruption of the second permanent molar.

AliKofide and AliNamankani 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 showed a strong inverse correlation between internal cranio-cervical 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 cranio-cervical 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 lower arch dental crowding.

All selected subjects were divided into two groups based on lower arch dental crowding as determined by Nance’s space analysis. 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. 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. 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 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

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

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 Kreiborg26).
from the group with lower dental crowding and 10 from
the group without lower dental crowding) and Dah-
lieberg’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 ver-
sion 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 ex-
isted 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 ex-
cess space of 1.09 mm (DS = 2.2). Means and stan-
ard deviations of the craniocervical, craniovertical, 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 cranio-
cervical 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 differ-
ce was found ($P \leq .1$).

DISCUSSION

The present study shows a clear pattern of associ-
ation between more than 2 mm of lower arch crowding
(left to right first molar included) and extended cranio-
cervical 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 Son-
nesen’s 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 the-
ory, the teeth and facial skeleton are submitted con-
stantly 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 stated that in dental skeleton modific-
a tions, 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 for-
mulated by Solow and Kreiborg 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 hyperexten-
sion 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 in-
duce a dorsal and caudal restraint on facial develop-
ment and a retroinclination of the incisors with a con-
sequent loss of correct alignment. Normal head pos-
ture can induce relaxed soft tissues with consequent
sagittal development and proclamation of the incisors.

The association between head posture and lower
arch crowding could also explain the reports of Linder-
Aronson and Woodside et al. They showed that sub-
jects 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 af-
after adenoidectomy, and with the return of nasal res-
spiration, an increased inclination of the incisors result-
ed.

A reduction of the nasal airway can cause, by reflex,
a hyperextension of the head to facilitate air passage.
An increase of the craniovertical angles is demon-
strated in children with adenoids, with enlarged ton-
sils, nasal allergy, and in patients with obstruc-
tive sleep apnea.
The experiment of Vig et al.\(^{11}\) demonstrated that when the nasal airway is obstructed, internal cranio cervical 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...
increases in cases of extended craniocervical posture, in order to the equilibrium theory\textsuperscript{23} it is important to consider if a correlation exists between an increased the craniocervical angle and tongue forces. In 1981, Wood\textsuperscript{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\textsuperscript{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.

REFERENCES


31. Thuer U, Janson T, Ingervall B. Application in children of a

