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RELATIONSHIP BETWEEN CERVICAL COLUMN MORPHOLOGY AND SKELETAL DEEP BITE: A PILOT STUDY


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Authors declare no conflict of interest

Abstract:

**Purpose:** Previous studies have shown that cervical column morphology is related to head posture, which is associated with craniofacial morphology such as mandibular rotation pattern. Furthermore, cervical column deviations and fusions have been linked with vertical and sagittal facial morphology. In addition, skeletal deep bite may lead to respiratory and swallowing difficulties, aesthetic and functional problems, as well as TMJ and facial pains. The aim of this study was to examine the cervical column morphology in adult patients with skeletal deep bite and to compare it with that of the control group with neutral occlusion and normal craniofacial morphology.

**Methods:** In a case–control study, 25 deep bite patients (17 female, 8 male), aged 17–30 years were compared with 25 controls (16 female, 9 male) of the same age range. For each individual, angular measurements of craniofacial and cervical column dimensions were made on profile radiographs. Anomalies of cervical column such as fusion and arch deficiency were assessed. Jarabak index, ANB, SN-MP, and FMA angles were also evaluated.

**Results:** In the deep bite group, 72% of patients had cervical column fusion compared to 32% of control sample. In the control group, the fusions were always occurred between C2 and C3. However, fusion in the deep bite individuals occurred in the C2-C3, C3-C4 and C4-C5 sites. Fusion occurred significantly more often in the overbite group compared with the control group. (p < 0.001).

**Conclusion:** Associations between skeletal deep bite and cervical column deviations are evident. Most significant deviation in cervical vertebrae was observed at C2-C3 intervertebral space.

Keywords: Cervical Column, Overbite, Skeletal Deep Bite

Introduction

Clinicians can use cephalometric radiographs as a potential resource to screen for pathologic abnormalities of the cervical spine and avert some pathologic complications. Morphological deviations of the upper cervical vertebrae have been described in relation to craniofacial abnormalities and syndromes (1). The cervical spine has been an interest area for orthodontists. Natural head position has commonly been assessed on lateral cephalograms using the cervical spine as the reference structure (2). Different anomalies of cervical vertebrae (fusions and posterior arch deficiency) have been reported to occur in patients with cleft lip and palate (3, 4), craniofacial syndromes (5), sleep apnea (6), and different dentoskeletal malocclusions (7-10). It has previously been shown that the head and neck posture is associated with craniofacial morphology (7, 11, 12). As the morphology of the cervical column is associated with head posture and head posture itself is linked with craniofacial morphology, it could be assumed that there is an association between the structure of the cervical column and the vertical dimensions of the face. Some researchers have confirmed that cervical fusions and craniofacial morphology may be interrelated in twins when analyzed on profile radiographs. Their findings also demonstrated that differences in cervical column morphology could occur among monozygotic (MZ) twins, which illustrated that differences in craniofacial morphology between individuals within a pair of MZ twins could be associated with cervical fusion (13).
The posture of the neck seems to be strongly associated with the sagittal as well as the vertical structure of the face (14). Fusion anomalies were associated with a large sagittal jaw relationship, retrognathia of the jaws, large inclination of the jaws, and extended head posture. Furthermore, a partial cleft was significantly associated with a large cranial base angle (15).

All of these studies have not shown any difference in regard to age and gender (7-15). However, most of them were performed on a selected European population, and there has been a paucity of research on this topic in other ethnicities such as the Persian (Iranian) population. The aims of the present study were, therefore, to describe the morphology of the cervical column in selected Persian adult patients with a skeletal deep bite based on lateral cephalogram and to compare the morphology of the cervical column in those patients to that of a control group with neutral occlusion and normal craniofacial morphology.

**Materials and Methods**

138 individuals were selected from patients presented to the clinic at Tehran Azad Dental School for routine dental visit. All subjects were from Persian ethnicity with both mother and father from Persian background. Participation was based on sequential sampling until inclusion of 50 patients. Twenty five deep bite patients were compared with 25 controls. Sample size was determined in accordance with similar studies (7, 8, 10). Sampling was based on the study purpose, and lateral cephalogram was utilized to diagnose any skeletal abnormality. Lateral cephalograms were obtained in natural head posture. Patients were selected within the age of 17-30 with no history of orthodontic treatment, orthognatic surgery, TMJ disorders, respiratory disorders, syndromes, and head and neck burns, scars or wounds. Individuals with interfering variables such as tongue habits and abnormal tongue posture were excluded. Extreme abnormal tongue posture was evaluated clinically by an orthodontist. All subjects signed written informed consents upon receiving thorough description of the study aim and setting. Individuals in the 5th stage of cervical maturation were selected (16) and were matched based on age and sex in between the groups. On the profile radiographs, a single observer assessed fusion anomalies and cervical curvature, as well as, the head posture.

The entire procedure was in accord with ethical and professional conduct in the dental practice and research, formulated and disseminated by “University Medical Ethics Committee”.

Craniofacial indices in both sagittal and vertical dimensions were measured. In order to make the measurements blind, the cephalograms were cut in halves to separate the cervical column prior to measurements. The study population was divided into case and control groups based on cephalometric indices and growth patterns. ANB = 2±2 measurement was considered an inclusion criteria for all the cases in this study. Assigning samples to each of the control and deep bite group was based on Jarabak index. Subjects with Jarabak ratio more than 65% were assigned into deep bite group.

Some of the measurements and cephalometric landmarks that were used in present study are described below:

- **Mandibular Plane Angle (MMA)**: The mandibular plane is considered to be a measure of vertical growth pattern, the greater (higher) the angle, the more vertical the growth direction.
- **Upper Anterior Facial Height (UAFH)**: A line connecting N to ANS
- **Lower Anterior Facial Height (LAFH)**: A line connecting ANS to Me
- **Jarabak Index (facial height ratio)**: Compares posterior facial height (S-Go) and anterior facial height (N-Me).

Then, indices of cervical vertebral column morphology were measured on lateral cephalograms (Fig. 1). Fusion of the vertebrae was detected by assessment of the opposing articular surfaces of vertebrae. Characteristics of the cervical column were classified according to Sandham (17) and divided into two categories: ‘posterior arch deficiency’ and ‘fusion anomalies’. Posterior arch deficiency consisted of partial cleft and dehiscence. Fusion anomalies consisted of fusion, block fusion, and occipitalization. While assessing the cervical column morphology, the author remained blind to the group type (deep bite or control) as cephalograms were cut in halves. Simultaneous occurrence of several cervical anomalies (ie. fusion, posterior arch deficiency) denominated as “several cervical deviations”. In the normal cases, clear radioluency was evident between the articular surfaces of vertebrae, indicating the intervertebral disk. However, in cases with fusion, the radioluency was either less than 1mm or completely absent (on actual size X-rays). The latter indicates incomplete fusion, while the former demonstrates incomplete fusion (Fig. 2, 3).
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SPSS 19.0 was used for statistical analysis. A p value <0.05 was considered statistically significant. All the data were analyzed with T-test and assessed by multiple regression tests. Evaluations of variables in both the case and control group were carried out using “Independent Sample T-test”. For vertebral fusion presence and location, “Fisher exact test” was applied, and for fusion number “Mann Whitney test” was used. For assessment of variables in relation to fusion “Backward Binary Regression” test was performed.

### Results

Age and sex distribution in groups is illustrated in Table 1. Using “Independent Sample T-test” the following results were obtained: a statistically significant difference was found between deep bite and control groups for FMA angle dissimilarity (p < 0.001); however, there were no significant difference between the groups for Jarabak Index and SN-MP.

Measurements in the control group with normal growth pattern were: Jarabak Index: 62-65 %, FMA angle: 23.6-28.1, SN-ML: 31.8 ± 5.2, UAFH/LAFH: 0.71 ± 0.08. Measurements in the case group with horizontal growth pattern and skeletal deep bite were: Jarabak Index > 65%, FMA angle < 23.6, SN-ML < 26.

For vertebral fusion presence and location, “Fisher exact test” was applied, and for fusion number “Mann Whitney test” was used. For assessment of variables in relation to fusion “Backward Binary Regression” test was performed.

### Table 1. Sample size and distribution

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Gender</th>
<th>Total N.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>N.</td>
<td>%</td>
<td>N.</td>
</tr>
<tr>
<td>Deep bite</td>
<td>20.4±3.79</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>Normal</td>
<td>8</td>
<td>32</td>
<td>17</td>
</tr>
</tbody>
</table>

### Table 2. Fusion and anatomic deviation results

<table>
<thead>
<tr>
<th>Cervical Vertebrae</th>
<th>Controls</th>
<th>Deep Bite</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.</td>
<td>%</td>
<td>N.</td>
</tr>
<tr>
<td>Normal</td>
<td>17</td>
<td>68</td>
</tr>
<tr>
<td>Fusion</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Several Deviations</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

### Discussions

The modifications in size and shape of the cervical vertebrae in growing subjects have gained increasing interest in the last decades as a biological indicator of individual skeletal maturity. One of the main reasons for the rising popularity of the method is that the analysis of cervical vertebral maturation is performed on the lateral cephalogram of the patient’s head, a type of film used routinely in orthodontic diagnosis. The anticipated anomalies of the cervical column were vertebral fusion and posterior arch deficiency of atlas, both detectable on lateral cephalogram.

In a study by Sonneston et al. no statistically significant gender differences were found in the occurrence of morphological characteristics of the cervical column (females 43.5%, males 38.9%). Morphological deviations of the cervical column occurred significantly more often in the deep bite group compared with the control group (p < 0.05) (10). In this study most of the fusions were found in C2-C3 site which is consistent with other studies (6, 10).

In Sonnesen’s study, correlation analysis showed that the vertical jaw relationship and the vertical overbite were significantly positively correlated with fusion of the cervical column, while upper incisor inclination was significantly negatively correlated with fusion. Furthermore, the vertical jaw relationship, jaw angle, upper incisor inclination, and lower alveolar prognathism were significantly negatively correlated with posterior arch deficiency. These associations were not due to age or gender. The significant Spearman correlation coefficients were low to moderate, numerical values ranging from 0.25 to 0.45. Logistic regression analysis showed that the vertical jaw relationship (p < 0.05), overbite (p < 0.001) and upper incisor inclination (p < 0.01) remained significantly correlated with fusion of the cervical column (r = 0.40). SN-MP, FMA and Jarabak Index were related to fusion (10). However, in the present study only FMA was related to fusion. Such discrepancy could be a result of ANB = 2± 2 condition for all the cases in this study.
An explanation for the association found in the present study between the cervical column, deep bite, and vertical craniofacial morphology may originate from the histological inductions from the notochord to the neural crest cells determined for the craniofacial morphology before the notochord disappears (18).

One of the merits of cervical column assessment on the lateral cephalograms is simply the fact that majority of population undergo orthodontic treatment planning and radiographic evaluation of craniofacial compartments at younger ages. Establishing any correlation between cervical abnormalities which are quite distinctive in cephalograms could really be beneficial in diagnosis or predicting the chance of deep bite occurrence. In Sonnesen’s study, fusion occurrences in control group (14.3%) and deep bite group (41.5%) are lower than correspondent results in this study (32% for controls and 72% for deep bite group). This fusion discrepancy might be a result of false-positive judgments which could have led to a higher report of malformations in our study; however, posterior arch deficiency was rare in both studies (9.8% and 12% respectively). In fact, growth-based superimposition of the radiographs disclosed that no patient showed actual fusion, even though the lateral cephalometric analysis revealed sufficient extreme skeletal patterns, which have been previously related to vertebral fusion.

As for the relationship of cervical vertebral maturation and mandibular growth changes, some studies (19) evaluated annual lateral cephalometric radiographs and found statistically significant increases in mandibular length and ramus height in association with specific maturation stages in the cervical vertebrae. Based on a study by Baccetti and colleagues, improvements in overbite cannot be predicted on the basis of skeletal vertical relationships. Thus, predicting a relation between cervical fusion and vertical mandibular growth does not seem to be reliable. However, it is wise to consider the fact that in their study deep bite was measured based on overbite measurement of 4.5mm and more. Dental overbite does not seem an appropriate criterion for assessing the skeletal deep bite. In the present study, patients were divided into groups based on Jarabak index as described by Bishara and Zaher (20, 21). Jarabak index is defined as the ratio of anterior to posterior facial height. Skeletal deep bite cannot be expressed merely based on dental landmarks such as overbite, as it is the product of both dental and skeletal developmental pattern and such association between dental landmarks with cervical and craniofacial growth patterns is remarkably subjective.

It has been assumed by many investigators that extreme values of mandibular plane angle were prognostic criteria for predicting the direction of facial growth. However, others suggested that a high mandibular plane angle is not a good predictor of facial growth and that individuals with high mandibular plane angle could have both backward and forward mandibular growth patterns (22, 23). At the other hand, in the present study FMA showed a significant change in the presence of cervical fusion. This finding may suggest association between cervical column with both backward and forward mandibular growth pattern.

D’Attilio et al noticed a significant relationship between the position and length of mandible and cervical. Lippold et al confirmed the correlation between the position of mandible and cervical vertebrae morphology (24, 25). The present study was in accord with both of these studies. The basilar part of the occipital bone guides the formation of the cervical vertebrae (26). Studies show that the notochord through its signaling induces the formation and development of body of the cervical vertebrae and basilar part of the occipital bone. Via some other signals, the notochord affects the paraxial mesoderm and induces the formation of spinal curve and parts of the occipital bone (27, 28).

Results from the present study and similar researches highlight the need for further investigations in the fields of genetics and primary stages of fetal development for better understanding of factors influencing the formation of skeletal malocclusions. Such studies may help in better recognition of phenotypic differences in patients with skeletal malocclusions (which are due to different genotypes) and their relationship to cervical anomalies.
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Conclusion

To conclude, associations between skeletal deep bite and cervical column deviations are evident. Most significant deviation in cervical vertebrae was observed at C2-C3 intervertebral space. However, subjective visual examination of a cephalogram may result in a false-positive finding and does not enable reliable diagnosis of cervical vertebrae anomalies (29); thus, repeating similar studies based on CBCT for confirmation is recommended.

References


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