Association between Condylar Position and Tilt of Frontal Occlusal Plane in Patients with Transversal and Vertical Dentofacial Discrepancy

SUMMARY

Asymmetric malocclusion is a common problem in children with transverse and vertical dental anomalies. These asymmetries can be skeletal, dental, functional or combination of these. The aim of this study was to determine condylar position and quantifying inclination of frontal occlusal plane in patients with transversal and vertical dentofacial discrepancy.

The study group consisted of 80 patients, 40 had unilateral posterior cross-bite, and 40 had normal occlusion. The age of the patients ranged between 13 and 18 years. In addition to transversal and vertical clinical observation, Ricketts facial PA cephalometric analysis was made. Radiographic analysis showed the relationship between the cant of the occlusal plane and mandibular position.

The obtained results showed that there was a very high statistical significance (p<0.001) for cephalometric measurements inclination of occlusal plane Z1-A6/Zr-A6 between the 18 patients with unilateral cross-bite and patients with normal occlusion. Mandibular displacement, facial asymmetry and strongest correlation with condyle path asymmetry were found in the experimental group. Unilateral cross-bites were very often associated with condylar deviations and, in some cases, signs and symptoms of temporomandibular joint disorders were present.

Keywords: PA Cephalometric Analysis; Unilateral Cross-bite; Condylar Deviation; Occlusal Plane, inclination

Introduction

The relationship between dentition and orofacial skeletal structures is not always harmonious and it depends on tooth number and position in dental arch. Identification of dental or skeletal factors, negative influence of growth and development, and tooth eruption is necessary to prevent orofacial malocclusion. Modelling of bone occurs as a result of different growth, of interrelated anatomic skeletal parts in orofacial region, influence of the function in orofacial region and forces applied on bone.

Asymmetric malocclusion is a common problem in children with transverse and vertical dental anomalies. These asymmetries can be skeletal, dental, functional or combination of these. Patients who have transversal discrepancies usually have mandibular displacements and, if left untreated, they can lead to skeletal deformation with vertical asymmetry of the mandible, such as inclination of the frontal occlusal plane and inclination of the frontal mandibular plane.

Growth in the transverse dimension happens earlier than in the sagittal or vertical dimension and hence early treatment is necessary. Early treatment can prevent associated mandibular dysfunction and facial asymmetry caused by posterior cross-bites. However, mandible displacement may not be all or even part of the cause of a craniomandibular dysfunction because orthodontic treatment may be responsible for the different degrees of symmetry.

Patients with asymmetric malocclusion have lateral displacement of the mandible because the maxillary
arch is too narrow, the mandibular arch is too wide, or the maxillary arch is too wide and the mandibular arch is too narrow, and a combination of these situations. Some asymmetries are genetic in nature. Of prime importance is the fact that uncorrected cross-bites can produce undesirable growth and dental compensations that may lead to asymmetric jaw growth. Mandible lateral displacement is clinically characterized by deviation of the chin, dental midline discrepancy and facial asymmetry; patients have cross-bites in the posterior region, and high prevalence of the internal temporomandibular joint derangement.

Mandibular displacements are present in most unilateral posterior cross-bites. Patients have a deflective dental contact, resulting in a functional shift on closure. This functional shift can cause unbalanced muscular activity, with hyperactivity on the cross-bite side. This type of muscular hyperactivity has been shown to influence the size and shape of the developing temporomandibular joint. Deviation of the midline when the mouth is wide open suggests a mandible laterognathia.

Diagnosis of temporomandibular joint disorders is very difficult and confusing. In most cases, there is a need of detailed medical history for complete evaluation of temporomandibular disorder, including patient’s description of symptoms and physical examination of the face and jaw movement. Complete medical history may be useful for making a correct diagnosis.

The aim of this study was to investigate the relationship between dental and skeletal morphologic changes in patients with transversal and vertical dentofacial discrepancy, and to determine condylar position and inclination of frontal occlusal plane.

**Material and Method**

The study group consisted of 80 patients, 40 had unilateral posterior cross-bite on the left side, and 40 patients had normal occlusion, and they were the control group. The age of the patients ranged between 13 and 18 years, with equal sex distribution. Ricketts facial PA cephalometric analysis was used as a method for transversal and vertical clinical observation. This analysis was made on the cephalometric films by standard methods.

![Figure 1. PA cephalometric film](image1)

The transversal and vertical landmarks, reference lines and measurements, used in the PA analysis (Fig. 2), are useful for determination of:

- cranial width (Zr–Zl), distance between lateral left and right zygomatico-frontal landmarks;
- facial width (ZA-AZ), distance of the left and right zygion point on the zygomatic arch;
- maxillary width (Jl-JR), distance between point jugale located on the maxillary corpus; and
- mandibular width (AGol-AGor), distance between bigonial point.
Other cephalometric measurements used in this analysis were done to measure:
- dental arch width, inter-canine maxillary cephalometric width (A3-3A);
- inter-canine mandibular cephalometric width (B3-3B);
- inter-molar maxillary cephalometric width (A6-6A);
- inter-molar mandibular width (B6-6B);
- molar relation A6/B6, on the left side and molar relation on the right side 6A/6B.

Craniofacial angle showing the cross-bite type, is the angle between points zygomatico-frontale-antegonion-jugale <Zr-Agor-Jr, <Zl-Agol-Jl, and this angle presents maxillo-mandibular relation. Facial symmetry is shown with the left and right angle of the face, between points zygion-antegonion-zygomatico-frontale, <ZA-Agor-Zr, <AZ-Agol-Zl (Fig. 2).

The vertical reference plane showing the facial midline is between point spina nasalis anterior-menton (SNA-Me). This measurement presents maxillo-mandibular midline and it is constructed as a straight line passing through crista galli and anterior nasal spine (Fig. 2), perpendicular to the straight line between intersection of the innominate line of the greater wing of the sphenoid bone and the lateral orbital margins

On the frontal cephalometric radiographs, occlusal plane tilt is defined as a difference between the height of the occlusal plane at the distal side on the left and right molars to the line that connects zygomatico-frontal sutures (Zl-A6/ Zr-A6). This variable represents inclination of the frontal occlusal plane relation, which is usually warning of possible TMJ problem (Fig. 3).

![Figure 3. Linear cephalometric measurements for inclination and evaluation of occlusal plane (Zl-A6/A6-Zr)](image)

Symmetry in maxillo-mandibular region and type of the facial asymmetry is measured with linear cephalometrics - difference between point zygomatico-frontale and antegonion on the left and right side of the face (Zl-Agol), (Zr-Agor). This variable represents condylar position (Fig. 4). Bilateral facial asymmetries and development of the orofacial area can be better assessed with a transverse analysis of PA cephalometric radiographs. This analysis shows changes in vertical and transversal dimensions of the face.

![Figure 4. Linear cephalometric measurements for facial symmetry condylar position, and evaluation of maxillo-mandibular relation (Zl-Agol), (Zr-Agor)](image)

Data were analyzed using a statistical programme with means and standard deviations. Student’s t-test was used to determine statistical significance between the groups.

### Results

The results and comparison of the means of angular and linear skeletal dentofacial variables between patients with unilateral cross-bite and control group are presented in tables 1-3.

Results of facial, maxillary and mandibular skeletal cephalometric measurements are shown in table 1. Patients with unilateral posterior cross-bite had constriction of the maxillary corpus on the left side in the region of the point Jugale. Moreover, maxillary dental arch was smaller and maxillary first molar had palatal inclination (Tab. 1).

Results for angular cephalometric measurements obtained by Ricketts P-A analysis are shown in table 2. Angle which shows cross-bite type <Zl-Ago-II was increased in comparison with normal values. Patients with posterior cross-bite had high values for the angle, 19.8°, which pointed to the skeletal lingual cross-bite.
Table 1. Linear facial and dental cephalometric measurements (mm) used in Ricketts PA analysis in patients with cross-bite on the left side

<table>
<thead>
<tr>
<th>Facial Cephalometric Measurements</th>
<th>Patients with unilateral cross-bite n=40</th>
<th>Patients with normal occlusion n=40</th>
<th>&quot;t&quot;</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zr - Zl</td>
<td>99.5 ± 4.2</td>
<td>102.0 ± 4.1</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>ZA - AZ</td>
<td>127.0 ± 5.4</td>
<td>132.2 ± 3.5</td>
<td>2.5</td>
<td>0.01**</td>
</tr>
<tr>
<td>Jr - Jl</td>
<td>65.7 ± 3.5</td>
<td>70.9 ± 4.5</td>
<td>4.3</td>
<td>0.001***</td>
</tr>
<tr>
<td>Agor - Agol</td>
<td>86.3 ± 3.3</td>
<td>88.9 ± 3.1</td>
<td>1.8</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Dental Cephalometric Measurements

<table>
<thead>
<tr>
<th>Dental Cephalometric Measurements</th>
<th>Patients with unilateral cross-bite n=40</th>
<th>Patients with normal occlusion n=40</th>
<th>&quot;t&quot;</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3 - 3A</td>
<td>33.2 ± 2.4</td>
<td>34.6 ± 2.7</td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td>B3 - 3B</td>
<td>29.2 ± 1.8</td>
<td>29.8 ± 2.6</td>
<td>0.8</td>
<td>0.42</td>
</tr>
<tr>
<td>A6 - 6A</td>
<td>59.4 ± 3.5</td>
<td>63.7 ± 5.8</td>
<td>3.1</td>
<td>0.001***</td>
</tr>
<tr>
<td>B6 - 6B</td>
<td>61.2 ± 3.5</td>
<td>62.3 ± 5.7</td>
<td>0.8</td>
<td>0.416</td>
</tr>
<tr>
<td>A6 / B6</td>
<td>0.91 ± 0.8</td>
<td>0.9 ± 0.5</td>
<td>0.1</td>
<td>0.882</td>
</tr>
<tr>
<td>6A / 6B</td>
<td>-1.97 ± 1.1</td>
<td>1.0 ± 0.5</td>
<td>3.4</td>
<td>0.001***</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01; *** p<0.001

Table 2. Angular cephalometric measurements used in Ricketts PA analysis

<table>
<thead>
<tr>
<th>Cephalometric angular measurements</th>
<th>Patients with unilateral cross-bite n=40</th>
<th>Patients with normal occlusion n=40</th>
<th>&quot;t&quot;</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;ZA-Agor-Zr</td>
<td>14.7 ± 1.93</td>
<td>16.6 ± 2.4</td>
<td>0.19</td>
<td>0.25</td>
</tr>
<tr>
<td>&lt;AZ-Agor-Zl</td>
<td>13.6 ± 1.91</td>
<td>16.3 ± 1.8</td>
<td>1.19</td>
<td>0.05*</td>
</tr>
<tr>
<td>&lt;Zr-Agor-Jr</td>
<td>15.5 ± 1.5</td>
<td>14.3 ± 2.3</td>
<td>2.5</td>
<td>0.01**</td>
</tr>
<tr>
<td>&lt;Zl-Agor-Jl</td>
<td>19.8 ± 1.96</td>
<td>14.7 ± 1.7</td>
<td>9.24</td>
<td>0.001***</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01; *** p<0.001

Table 3. Cephalometric measurements (mm) for condylar position and inclination of occlusal plane

<table>
<thead>
<tr>
<th>Cephalometric linear measurements</th>
<th>Patients with unilateral cross-bite n=18</th>
<th>Patients with normal occlusion n=40</th>
<th>&quot;t&quot;</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zr - Agor</td>
<td>97.16 ± 2.57</td>
<td>101.1 ± 4.5</td>
<td>2.01</td>
<td>0.01*</td>
</tr>
<tr>
<td>Zl - Agol</td>
<td>94.66 ± 2.63</td>
<td>101.2 ± 3.5</td>
<td>2.98</td>
<td>0.01**</td>
</tr>
<tr>
<td>Zr - A6</td>
<td>73.55 ± 3.36</td>
<td>76.6 ± 2.3</td>
<td>1.96</td>
<td>0.5*</td>
</tr>
<tr>
<td>Zl - 6A</td>
<td>73.47 ± 3.35</td>
<td>76.6 ± 3.5</td>
<td>1.96</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

* p<0.05; ** p<0.01; *** p<0.001
Results from PA cephalometric study provided useful information for condylar position ZI-Ago and inclination of occlusal plane ZI-6A. Results from these measurements in patients with unilateral posterior cross-bite are presented in table 3. Out of 40 patients, 18 had inclination of the occlusal plane and mandibular displacements.

Discussion

Orthodontic diagnosis is mostly based on the use of cephalometric radiographs as a diagnostic tool. Transversal and vertical components are easily viewed from lateral cephalograms, but cannot be fully understood without the assistance of PA cephalometric analysis. Roentgenograms, such as the postero-anterior view, submental vertex, 3-dimensional image of the patients’ face, and computerized tomography images are important methods for diagnosis and quantification of dentofacial transversal and vertical discrepancies and facial asymmetries.

Diagnosis of unilateral and bilateral vertical asymmetries and development of the orofacial area can be better assessed with frontal transverse analysis of PA cephalometric radiographs. PA cephalogram, in fact, contains important diagnostic information, which shows level and type of facial asymmetries. Patients with lateral occlusion and midline shift can be observed in occlusal position. In patients with laterognathy, the midline shift can be observed in both situations, in occlusal position and when the mouth is wide open. If cross-bite and lateral occlusion are not treated during growth, they can lead to asymmetric jaw growth. Degree of asymmetry in the vertical dimension significantly correlated with TMJ symptoms.

PA cephalometric analysis is more conservative than 3-dimensional image of the patients’ face or computerized tomography images. This analysis gives opportunity to show the severity of the skeletal problem. Analysis of PA cephalograms in this study showed that patients with unilateral posterior cross-bite had a constriction on the maxillary corpus in the point jugale and smaller maxillary dental arch in inter-molar region. Mandibular arch was within normal parameters. PA roentgenograms showed that maxillary width had lower values in patients with unilateral cross-bite (65.7 mm). These values compared with the values of the patients with normal occlusion (70.9 mm) showed a very high statistical significance (p<0.001). Therefore, the patients with a cross-bite had a statistically significantly smaller palatal volume with skeletal constriction on the maxillary corpus.

Angle between point zigomatico-frontale and antegonion <Z-Ago-J, denoting the cross-bite type, in patients with unilateral posterior cross-bite had a value of 19.8 degree, compared to that in the control group (p<0.001). The value of this angle showed that patients had skeletal lingual cross-bite.

PA cephalograms showed mandible asymmetry in 18 patients; they had inclination of the frontal occlusal plane for 3 mm (ZI-A6/ Zr-A6). The results suggest that the degree of asymmetry in the vertical dimension was statistically significant (p<0.01) and the inclination correlated with TMJ disorder symptoms. Irregular dental occlusion had also influence on the changes in cant of the occlusal plane; differences in the heights of the right and left mandibular rami have been suggested as important skeletal problem associated with TMJ pathology. Our analysis was in agreement with the reports in similar studies. Patients with facial asymmetry had shifted position of the mandible, which showed the strongest correlation with condyle path asymmetry. Unilateral cross-bites are very often associated with condylar deviations and in some cases are signs of TMJ disorders. Analysis of frontal PA radiographies in this study showed that patients with cross-bite had: lingual inclination of maxillary buccal teeth, constriction of the maxillary corpus on the level of the point jugale, skeletal, lingual cross-bite, and facial asymmetry. Our results coincide with the findings presented in the studies of Hewitt and Kusayama.

Many studies have defined geometric and mathematical relationships between dental occlusion and rotations of the occlusal plane in the frontal view. As a general clinical guide, each degree of rotation of the occlusal plane will result in a half-millimetre change in the dental occlusal relationship. This is important since changes in the cant of the occlusal plane are sometimes unintentional, as well as intentional, during occlusal therapy. The distance in millimetres between the facial midline and the midline of the mandible incisors has been described as the dental midline shift. A dental midline shift on the left and right side was considered as the absolute value for diagnostic criteria for transverse asymmetry.

Asymmetrical patients have also been found to have a higher incidence of morphological changes and internal TMJ derangement on the shifted side when compared to the non-shifted side and it has been suggested that the incidence of disk displacement and TMJ disorder symptoms on the deviated side is higher than on the non-deviated side.

An insufficient maxillary arch width in our study is a typical finding in the unilateral posterior crossbite. Functional shift results in lateral mandibular displacement, and thus, there is a mandibular midline discrepancy. When the maxilla is severely constricted, a bilateral posterior cross-bite is present.

Causes of asymmetric malocclusion are multifactorial. O’Byrn suggested that congenital malformations, digital habits, interproximal caries and
extractions can influence the dental arch symmetry. Transversal and vertical discrepancy in orofacial region are malocclusions with a wide range of symptoms, leading to skeletal and dental arch deformities, tooth malposition, masticator disturbances, TMJ disorders, and facial asymmetry. Woodside and Linder-Aronson listed a number of factors that were contributory to malocclusions and altered skeletal relationships. Several studies confirmed the following contributory factors: genetic predisposition, enlarged adenoids, enlarged tonsils, allergic rhinitis, sleep apnea, deviated nasal septum, altered mandibular posture, altered tongue posture, extended head posture, incorrect orthodontic treatment, weakness in the muscles of mastication, and thumb sucking. Most TMJ problems are multifactorial in origin, including a number of possible causes, such as condylar deviations and TMJ diseases, or irregular dental occlusion. Asymmetry of the mandible shows a high incidence of TMJ disorders.

Functional shift of the mandible in children with unilateral posterior cross-bite results in an asymmetric position of condyle and suggests that this functional shift may transmit forces to the skeleton, resulting in asymmetry in the adult. This asymmetrical function reflects different development of the elevator muscles on each side of the jaws, leading to a thinner masseter muscle on the cross-bite side. Hesse described that uncorrected cross-bites may lead to restriction of maxillary growth and traumatic occlusion, producing undesirable growth and dental compensations that may lead to asymmetric jaw growth, and mandibular displacement resulting in facial asymmetry. Differences in the heights of the right and left ramus mandible have also been suggested as important skeletal problems associated with TMJ pathology.

Occlusal instability, midline discrepancy, right and left differences in molar relationship, and inclination of the frontal occlusal plane have also been considered to be important occlusal characteristics in patients with unilateral posterior cross-bite.

In patients with posterior cross-bite and midline deviation orthodontic treatment is necessary to rehabilitate the asymmetric muscular activity between the cross-bite and the other side and the changed position of the condyle caused by mandibular deviation. The success of the treatment rests on the presence of skeletal or dental changes. Skeletal asymmetries are preferably treated with a combination of orthodontics and orthognathic surgery. Dental and small skeletal asymmetries and functional mandibular asymmetries are most often treated with orthodontic therapy. A combination of orthodontic and orthopaedic treatment has been shown to correct the maxillary transverse deficiency, allow better mandibular growth and improve facial and dental aesthetics. When patients have problems in transversal maxillary development, maxillary expansion is the treatment of choice for posterior cross-bite; correction of maxillary transverse deficiency allows better mandibular growth, proper bucco-lingual relations and good intercuspidation, resulting in normal function.

Early diagnosis and treatment will facilitate establishment of functional and aesthetic individual optimum to maintain the specific features of the concerned person, and will correct growth and development of the orofacial region.

References

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