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Occurrence of Maxillary and Mandibular Rotations in Patients with an Open Bite

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Abstract: Objective: *The aim of this study was to determine the occurrence of maxillary and mandibular rotations in patients with an open bite within a population attending a university orthodontic clinic.* ***Materials and Methods:*** *Cephalic radiographs from 103 subjects were used for the study. The gonial angle, subdivided into superior and inferior, as well as the angle formed by the maxillary line (ANS-PNS) and, the Pt line were measured to determine the rotations of the maxilla, the mandibular ramus, and the mandibular body.* ***Results:*** *Eighteen potential combinations between maxillary and mandibular rotations were found as contributing factors in open bites. The three most commonly seen combinations in the studied population were: a downwardly displaced body of the mandible with no rotation of the maxilla, associated with an anteriorly displaced mandibular ramus (31%); upward rotation of the maxilla with an anteriorly displaced ramus and a downwardly displaced body of the mandible (16%); and, an anteriorly displaced ramus associated with no rotations of the maxilla or the body of the mandible (11%).* ***Conclusions:*** *An open bite may present deviations from normal in the rotations of the maxilla, the mandibular ramus and/or the body of the mandible in up to 18 different ways. This may be important when determining the severity of an open bite and its treatment. The authors propose that the occurrence of maxillary and mandibular rotations may be associated with deviations in the craniofacial growth and development caused by dysfunctions in the oral and breathing patterns.*

Key words: *Open Bite; Maxillary rotation; Mandibular rotation; Malocclusion*

Introduction

Anterior open bite malocclusions is a vertical dysplasia frequently diagnosed and considered one of the most challenging treatments in orthodontics.[1] Their prevalence may be as high as 11%, which may vary depending on ethnicity and age.[2] Various structural alterations in the craniofacial complex may combine to produce an open bite.[1-5]

Available research is lacking a comprehensive answer for why skeletal anterior open bites exist. It is well known that there is not one single skeletal dysplastic factor that is present in every case.[6] This vertical dysplasia has been associated with an increased gonial angle,[7-10] a posterior rotation of the mandible,[9-11] a shorter anterior cranial base, upward and forward rotation of the maxilla, increased upper posterior dental height, increased lower anterior facial height, as well as dental pro-inclination.[5,9,10,12,13]

Open bites have been also associated with habits and anatomic abnormalities, such as mouth breathing, thumb sucking, tongue posture and/or hypertrophy of tonsils and adenoids.[14-17] Thus, a combination of congenital, morphological, biomechanical, and environmental factors is at play when evaluating the factors causing an open bite.[15] Therefore, understanding the skeletal factors associated with this type of malocclusion, establishing a proper diagnosis, and designing an ideal treatment plan for each case are critical.[4,7]

Currently, there is a lack of knowledge on the extent of the role of the rotations at the maxilla and mandible in the production of open bites. This stream of research may create an avenue for other studies to continue exploring alternative treatments based on the structural alterations associated with this type of malocclusion. In this study, it was hypothesized that both the maxilla and mandible may rotate in a counter-clockwise and clockwise direction respectively, when an open bite exists. Thus, it aimed to determine the presence and frequency of rotations in the maxilla, the mandibular ramus, and the body of the mandible in patients with an open bite, as well as how they may combine as contributing factors in the development and expression of an anterior open bite.

Materials and Methods

Study Design

Ethical approval (H2011:207: July 20, 2011) was received from the University of Manitoba Ethics Committee for the collection of human data on lateral cephalograms. A total of 3,609 patient files were searched and from those, 103 pre-treatment lateral cephalograms demonstrating the presence of a diagnosed anterior open bite were collected. The demographic data is presented in Table 1.

Upon identification, a digital photograph was taken of the 103 pre-treatment radiographs (Canon EOS Rebel T3 Digital Camera with a 50 mm lens). For that, the camera was positioned onto a tripod and used without zoom or flash. The

lateral cephalograms were individually placed on an illuminated radiograph viewer in a dark room using physical markers to standardize the image placement and capture. For that, a piece of white masking tape was attached to the upper right hand corner of the viewer for consistent positioning of the camera; thus, each photograph captured the piece of masking tape in the top right hand corner. Photographs were taken at a distance of 3 feet, which was marked with masking tape on the floor, to ensure consistent photographer positioning by standing on this masking tape while capturing each image. Digital photographs were then transferred to a computer. Finally, the digital photographs were printed to scale on standard white paper measuring 8.5" x 11" for the cephalometric measurements. The studied angles referred below were outlined and then measured by one of the authors by means of a protractor.

Cephalometric measurements

The following landmarks were identified: ANS, Articulare, Gonion 1 and Gonion 2 (top and bottom of Gonial curve, respectively), Menton, Nasion, Orbitale, PNS, Porion, and Ptm (middle of the superior surface of the pterygomaxillary fissure). Gonion was determined as a single point, which was that at the intersection of Gonion 1 and Gonion 2. From there, five linear measurements, which formed four angles, were traced: Ptm line (vertical line from Ptm and perpendicular to Frankfort); Maxillary line (ANS-PNS) and extended to cut the Ptm line; Mandibular Body line (Menton-Gonion); Mandibular Ramus line (Gonion-Articulare); and, Gonion-Nasion.

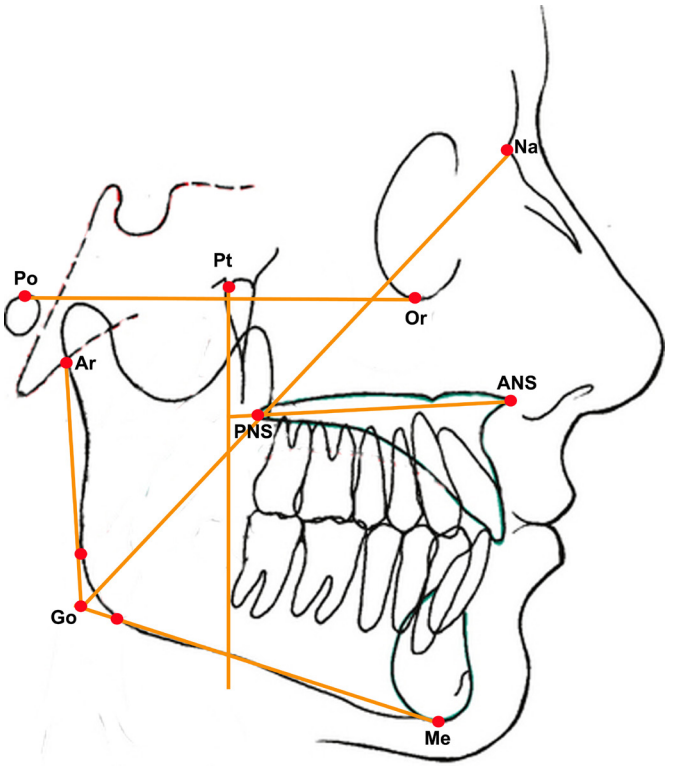

Figure 1: Drawing showing the cephalometric points and planes used to determine the angles used in the current study to evaluate the rotations of the maxilla, mandibular ramus, and mandibular corpus.

The angles formed by those lines were: Total Gonial Angle (Ar–Gonion–Menton); Gonial Superior (Ar–Gonion–Nasion); Gonial Inferior (Nasion–Gonion–Menton); and, Ptm line/ Maxillary Line (ANS-PNS). All measured angles are presented in Figure 1. Normative values and standard deviations for those angles were considered as follows: Total Gonial Angle 130 degrees SD +/-4; Superior Gonial Angle 55 degrees SD +/-2; Inferior Gonial Angle 75 degrees SD +/-2; and, Ptm line/ Maxillary Line 90 degrees SD +/-2. So, a superior Gonial (SG) angle greater than 57 degrees indicated that the ramus opened posteriorly, whereas a SG angle lower than 53 degrees indicated that the ramus closed anteriorly; an inferior Gonial (IG) angle greater than 77 degrees indicated that the body of the mandible moved in a clockwise direction, whereas a value lower than 73 degrees indicated that the body of the mandible moved in a counter clockwise direction. For the angle between the Ptm line and the Maxillary line, a value greater than 92 degrees indicated a counter clockwise rotation of the maxilla, whereas an angle less than 88 degrees indicated a clockwise rotation of the maxilla.

As mentioned above, all measurements were performed by one of the authors. Every angle was measured three times at different days, and the averages of the three measurements were used as final data.

Results

Eighteen combinations of maxillary and mandibular relationships conducive to an open bite were found in the population studied (Figure 2). The major group was composed of 31% of the population, which presented a clockwise rotation of the body and no rotation of the maxilla in combination with an anterior rotation of the mandibular ramus

Sixteen percent of the subjects showed a counter-clockwise rotation of the maxilla associated with an anterior rotation of the mandibular ramus and a clockwise rotation of the body of the mandible. Eleven percent of the subjects reported an anterior rotation of the mandibular ramus in combination with a normal positioning of the body of the mandible and the maxilla. Seven percent of the subjects presented a clockwise rotation of the maxilla with an anterior rotation of the mandibular ramus and a clockwise rotation of the body of the mandible. Seven percent of the subjects showed a counter-clockwise rotation of the maxilla in combination with a clockwise rotation of the body, but a normally positioned ramus.

Four percent of the subjects had a counter-clockwise rotation of the maxilla, with normally positioned mandibular body and ramus. Another 4% of subjects had a counter-clockwise rotation of the maxilla with an anteriorly rotated

Table 1: Demographics for the population included in the study

Gender		Age	
Female	59	Minimum	10
Male	44	Maximum	33
		Mean	17

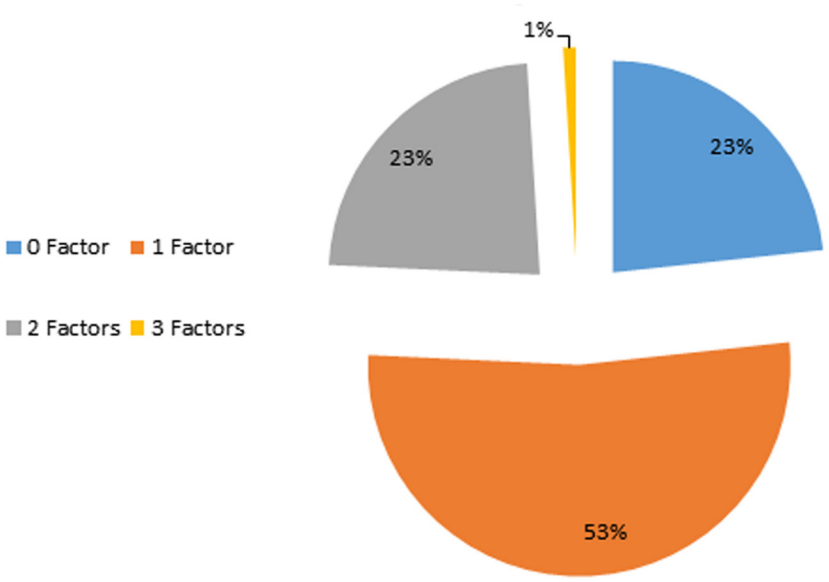

Figure 2. Graphic showing the percentages of the maxillary (1st letter), mandibular ramus (2nd letter), and mandibular body (3rd letter) rotations in the studied population diagnosed with an open bite. N= normal angular value, I= increased angular value, D = decreased angular value.

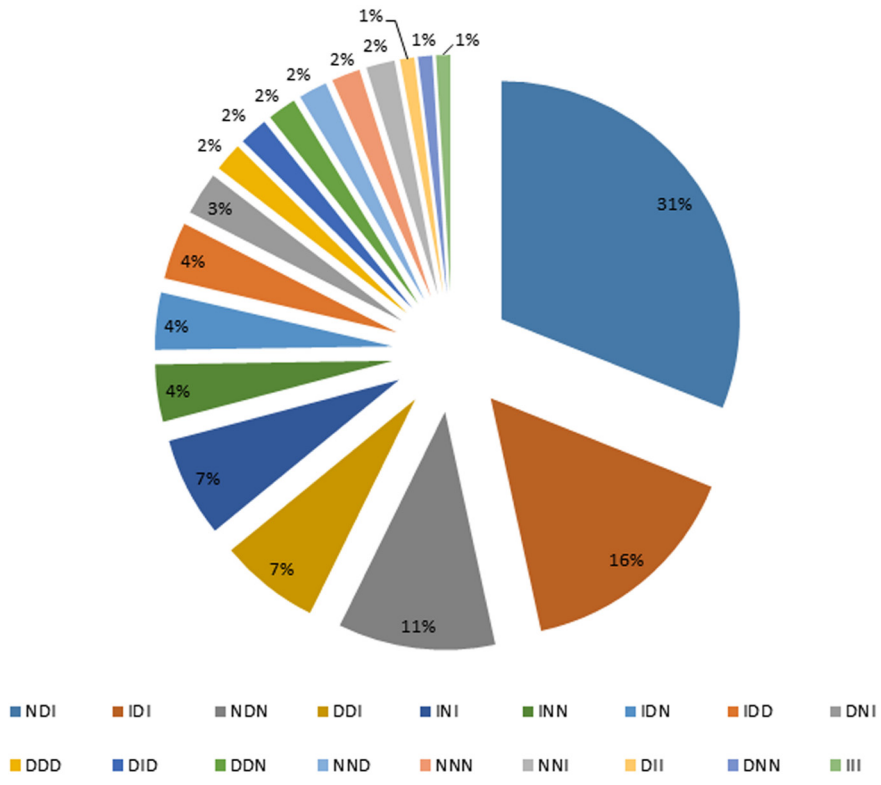

Figure 3. Graphic showing the incidence of the 3 contributing factors, presented as percentages, in the studied population diagnosed with an open bite.

ramus and a normally positioned body of the mandible. Four percent of subjects reported a counter-clockwise rotation of the maxilla, an anterior rotation of the maxillary ramus, and a counter-clockwise rotation of the body of the mandible. Three percent of the subjects had a clockwise rotation of the maxilla, a clockwise rotation of the body of the mandible, and a normally positioned mandibular ramus. Two percent of the subjects presented a clockwise rotation of the maxilla, an anterior rotation of the mandibular ramus, and an counter-clockwise rotation of the body of the mandible. Two percent of the subjects showed a clockwise rotation of the maxilla, a posteriorly rotated mandibular ramus and, a counter-clockwise rotation of the body of the mandible. Other 2% of the cases had a clockwise rotation of the maxilla, an anterior displacement of the mandibular ramus but a normally positioned body of the mandible. A normally positioned maxilla and mandibular ramus in combination with a counter-clockwise rotation of the body was found in two percent of the subjects. Similarly, 2% of the subjects had no rotation of the maxilla, the mandibular ramus, or the body of the mandible. Two percent of the subjects presented a normal positioning of the maxilla and the mandibular ramus in combination with a clockwise rotation of the body of the mandible. One percent of the subjects had a clockwise rotation of the maxilla with a posterior rotation of the mandibular ramus and a clockwise rotation of the body of the mandible. In 1% of the subjects, there was a clockwise rotation of the maxilla with a normally positioned mandibular ramus and body. Finally, 1% of the subjects had a counter clockwise rotation of the maxilla, a posteriorly rotated mandibular ramus, and a clockwise rotation of the body of the mandible.

Of all measured cephalic x-rays, 44% of the subjects exhibited a clockwise rotation of the body of the mandible, whereas 23% exhibited a clockwise rotation of the body of the mandible associated with a counter-clockwise rotation of the maxilla. Eight percent exhibited a counter-clockwise rotation of the maxilla only.

Finally, the study showed that 53% of the subjects had only one rotational factor contributing to the development of the open bite; 23% of the subjects present

a combination of two rotational factors contributing to the development of the open bite; and, only 1% of the cases had the three rotational factors studied here contributing to the development of the open bite. The percentages for the various combinations are presented in Figures 2 and 3.

Discussion

In the studied population, the majority of cases reported a higher involvement of the mandible as a factor causing the open bite comparing to the maxillae. In that context, these results tend to agree with some previous studies.[18,19] In some cases, the maxilla did play an etiological role as it rotated upward increasing the vertical dysplasia, but it most often did not. In that context, it looks like in the studied population the anterior open bite was due to deviations mostly in the mandible. Conversely, we can postulate that the maxilla may undergo a type of compensatory mechanism by rotating clockwise or downward in attempt to follow a downwardly rotating mandibular body or anteriorly rotating ramus. Perhaps this is a physiological buffer to reduce the severity of the open bite in cases where the ramus and/or body are deviating from ideal.

Previous studies have observed a small percentage of cases which exhibited all angular values within acceptable limits, therefore showing no rotation whatsoever and a purely dental open bite malocclusion without skeletal abnormality.[4,20] This study reported that 23% of the subjects presented no rotations in the maxillae, the mandibular ramus, or the mandibular corpus. In those cases, the open bite was strictly dental. In that way, it may be suggested that a smaller proportion of those patients diagnosed with an open bite could have a pure dental problem with no skeletal involvement.

The results from the current study also suggest that very few patients exhibit a posterior displacement of the ramus, whereas the majority of patients exhibit anterior displacement. Additionally, the majority of patients exhibit downward rotation of the body, rather than upward rotation of the body. In this patient population, open bite was unlikely to be contributed to by an upward rotation of the body of the mandible. Instead, the open bite may be mainly contributed to by anterior displacement of the ramus. It has been reported that an increased total gonial angle can cause open bite.[21] However, the present results suggest the ramus and body can rotate independently of one another and that the ramus and body can be associated with open bite independently or in combination. Based on the present results, it may be said that a higher prevalence of clockwise mandibular rotation is found in anterior open bites, associated with anterior rotation of the mandibular ramus, which could be a compensatory mechanism.[21,22] In that context, analyzing the superior and inferior gonial angles independently may lead to a more accurate diagnosis when evaluating an anterior open bite patient.

A clockwise rotation of the mandible was reported in most of the cases with open bite studied here. In that context, the authors propose that most of the open bite malocclusions may involve a disturbance in the breathing pattern and/or the position of the tongue at rest. For a patient to rotate the mandible in a clockwise direction, the suprahyoid muscles, particularly the geniohyoid, the anterior digastric and the mylohyoid, have to pull the mandible downward and backward. For that to occur, the tongue has to position low, resting either between the upper and lower incisors or on the floor of the mouth. In that context, the authors propose that the mandibular rotations observed in the patients studied here were caused by dysfunctional problems, such as mouth breathing and incorrect tongue posture, as it was reported in animal studies.[23,24] Therefore, it is important for the clinician to determine the skeletal problems involved when diagnosing a malocclusion. However, it is even more important to figure out the dysfunctions that may be involved causing those skeletal deviations, as different morphological variations may occur in humans, which may associate with neuro-muscular and soft tissue dysfunctions, as it has been demonstrated in animals.[25] Therefore, in order to reach a correct diagnosis and design the ideal treatment plan for each patient, it is important to determine the morphological variations involve in the malocclusion, as well as the associated oral and breathing dysfunctions.

Future research can be undertaken in this field to better clarify differential diagnoses for open bite in different patient populations. A study such as this one, with the addition of habit history for each patient, breathing patterns, and muscular dysfunctions could lead to a more complete diagnosis and tailored treatment modalities. A limitation of this study is that we were unable to address any co-occurring causative factors, including elements like habit history (e.g. thumb sucking), congenital abnormalities, or presence of a syndrome.

Conclusions

This study showed that there can be 18 different potential combinations of maxillary and mandibular rotations associated with open bite. The most common combination was a non-rotated maxilla with an anteriorly displaced ramus and a downwardly displaced body of the mandible. The authors propose that determining the deviations of the maxillae and mandible when diagnosing a malocclusion is important, but figuring out the factors that caused those skeletal deviations are even more important to reach a complete diagnosis and design an ideal treatment plan.

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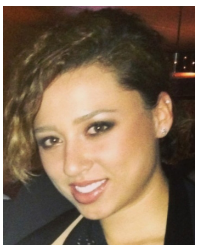

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Photo not available at time of printing.

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