

Skeletal morphologic features of Anterior Open Bite Malocclusion amongst black patients visiting the Medunsa oral health centre

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ABSTRACT

Introduction

Anterior open bite (AOB) malocclusion presents as lack of vertical overlap of anterior teeth. It is viewed to be unaesthetic and may affect speech and mastication.

It develops due to the interaction of hereditary and environmental etiological factors and these usually affect the vertical growth of the face. This study describes the vertical changes of South African black people presenting with AOB.

Aims and objectives:

The aim was to determine skeletal morphological features of patients with AOB malocclusion.

Design

The design was a retrospective, cross-sectional study.

Materials

Archived pre-treatment lateral cephalographs of 181 patients who consulted between 2007 and 2014 were divided into four groups: control group of 62 patients with skeletal Class I pattern without AOB; test groups of patients with AOB (119) divided into 35 Class I, 43 Class II, and 41 Class III malocclusions. Records of each group were divided according to gender. Descriptive statistics, the Pearson correlation coefficient, t-test and

Wilcoxon test were employed to analyze the data, and p values of ≤ 0.05 were considered statistically significant.

Results and conclusions

Patients with AOB had a larger vertical facial pattern in all classes of malocclusion. Males presented with larger Sn-GoGn angles than females. The PFH/AFH ratio was lower across all classes of malocclusion compared to the control group.

INTRODUCTION AND LITERATURE REVIEW

Malocclusion can occur in three planes of space, namely sagittal, transverse and in the vertical plane. The lack of dental occlusion in the oral cavity occurs in the vertical plane as either an open bite in the anterior area, an open bite in the lateral areas, or as a combination of the two.¹

Open bite malocclusion is considered as an abnormality in the vertical relationship of maxillary and mandibular arches. It is characterized by a lack of contact between opposing segments of teeth.^{2,3} The term "open bite" was first introduced by Caravelli in 1842.⁴ The incidence of AOB varies between races and ranges from 1,5% to 11%. Differences also occur with age as some AOB close spontaneously with increasing age.⁵

The clinical and radiological evaluation of AOB is complex and exhibit dental or skeletal components, or a combination of the two in some cases.¹ The dental open bite is associated with a normal craniofacial pattern of growth on the cephalometric radiograph and labial tipping of both upper and lower anterior teeth. The skeletal open bite shows vertical disharmony of craniofacial skeleton on the cephalometric radiograph and over eruption of posterior teeth.

A dental open bite can also affect the alveolus and has also been referred to as dento-alveolar, when there is a change in the vertical growth of the alveolar component. A skeletal open bite has features such as clock-

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wise or downward rotation of the mandible, tipping of the maxilla and diversion of the gonial angle of the mandible and the open bite usually extends to the posterior teeth.

The etiology of AOB is multifactorial with numerous theories such as environmental, genetic and anatomic factors often cited as culprits. Bjork⁹ reported that open bite malocclusion occurs as a result of environmental and genetic factors stimulating the vertical growth of the molar region which is not compensated by condylar growth. Forces that prevent eruption in the incisal region also contribute to the cause of AOB malocclusion.¹⁰

A mouth breathing pattern is a common condition and is due to constriction of the upper airway resulting from the presence of some form of physical obstruction of the airway such as enlarged adenoids and or tonsils, chronic sinusitis, swollen nasal turbinates and deviated nasal septatae.

The acidic air and many circulating allergens are common causative agents of most oronasal tissue infections leading to airway obstruction and subsequent mouth breathing. A prolonged open mouth posture leads to development of the AOB as a result of lack of contact of posterior teeth with resultant over-eruption of these teeth.^{3,5} A deviated nasal septum may impede normal breathing pattern and lead to AOB.

Anatomic factors that contribute to an anterior open bite will include a large tongue and a lower tongue posture at rest due to a mouth breathing habit. Neuromuscular deficiencies such as muscular dystrophy can also lead to anterior open bites due to a decrease in tonic muscle activity and inadequate mouth seal and support. This leads to the mandible rotating downward resulting in increased anterior facial height and posterior growth rotation of the mandible.^{4,5}

Genetic factors also play a role with some families genetically presenting with a vertical craniofacial growth and an AOB. Habits such as digit sucking may lead to AOB depending on the position of the digit, the duration of the habit and the magnitude and direction of the force applied by the digit against the surrounding structures.

A plethora of local factors: trauma to the condyle, osteoarthritis, infection and systemic factors: autoimmune diseases such as rheumatoid arthritis, ankylosing spondylitis, Sjogren syndrome and systemic lupus erythematosus to mention a few also cause AOB.

The classification of AOB is therefore complex and the current trend errs towards reliance on etiological factors. The classification of occlusion and malocclusion by Angle² was mainly directed to horizontal discrepancies of the maxillary and mandibular arches and did not include other planes of AOB.

Many studies have been done and much information obtained regarding the morphologic characteristics and specific areas of skeletal open bite malocclusion in dif-

ferent races.¹¹ Dawjee, Oberholzer and Hlongwa¹² reported that various cephalometric analyses are available to diagnose the morphological features of AOB malocclusion by authors such as Cangialosi.¹³

AIMS AND OBJECTIVES

The aim of this study was to assess the skeletal morphologic features in a black South African population with skeletal AOB malocclusion using cephalometric radiographs of untreated cases.

Studying and analyzing morphological features of this form of malocclusion may shed light on the possible prevention and early treatment strategies of this condition, and might help in establishing a protocol for its management.

DESIGN AND METHODS

The study was approved by the Medunsa Research and Ethics Committee of the University of Limpopo, Medunsa Campus (Project number: MREC/D/379/2014). Following the granting of permission from the hospital authorities, archived lateral cephalograms of untreated black patients in the Department of Orthodontics, University of Limpopo, Medunsa Campus were retrieved and used for the study.

A total of 181 lateral cephalograms (65 males and 116 females) were selected for this study. The criteria for selection were: incisor relationships with AOB of ≥ 1 mm; no history of orthodontic treatment or orthognathic surgery; lateral cephalometric radiographs of good quality according to acceptable standards that had been taken with the patient biting in centric occlusion. All patients selected were mature and above the age of 21 to avoid the effect of growth on the craniofacial structures

The analog cephalograms were taken with the Siemens, Orthopantomograph 10®, whereas the digital radiographs were obtained using the Kodak 8000C® X-ray machine. The analog cephalograms were digitized using the Vidar Sierra Advantage® X-ray film digitizer. The calibrations on the ruler served as a reference to enable adjustment for magnification of the image.

Dolphin Imaging 11.5 Premium® cephalometric analysis computer software was used to trace and analyze the cephalograms. The Nahoum¹⁴ analysis was utilized to confirm the magnitude of AOB malocclusion of the selected radiographs. The incisal edges of the maxillary and mandibular incisors were projected perpendicularly onto the facial plane (N-Me). The vertical distance between points **A** and **B** (Figure 1) was measured digitally.

The traced lateral cephalometric radiographs were divided into four groups according to skeletal classification, by using the ANB angle¹⁵, the facial plane angle¹⁶, the Wits analysis¹⁷, and convexity.¹⁸ The control group consisted of 62 lateral cephalometric radiographs of patients with skeletal Class I pattern without AOB.

The test groups consisted of 119 pre-treatment lateral cephalometric radiographs of black South African pa-

tients who presented with AOB malocclusion and were divided into three groups: skeletal Class I, II, and III malocclusions. The records of each group were divided according to gender. All the digitally-traced cephalometric radiographs were stored in a computer folder.

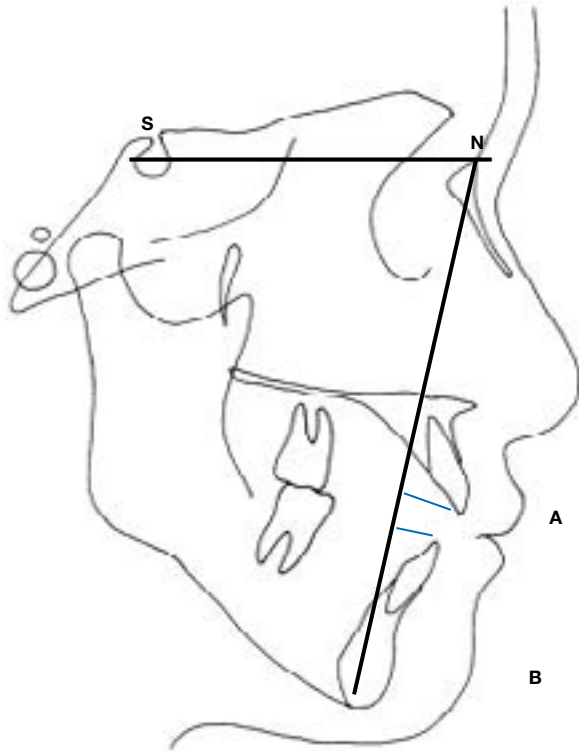


Figure 1. Measurement for AOB malocclusion on a lateral cephalometric radiograph. The incisal edges of the maxillary (A) and mandibular incisors (B) are projected perpendicularly onto the facial plane (N-Me). The vertical distance between points A and B is measured in millimeters.¹⁴

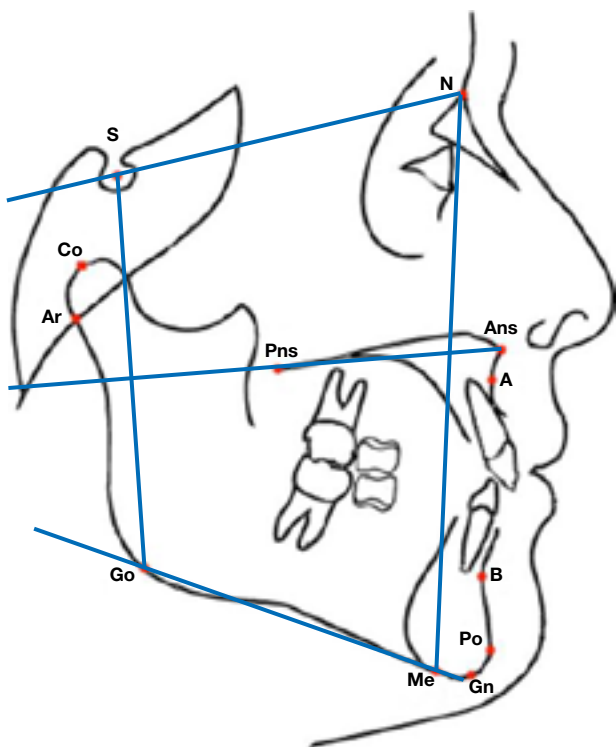


Figure 2. Cephalometric landmarks: sella (S); nasion (N); condylion (Co); articulare (Ar); posterior nasal spine (PNS); anterior nasal spine (ANS); A-point (A); B-point (B); gonion (Go); pogonion (Po); menton (Me); gnathion (Gn).¹⁷

Selection of landmarks and cephalometric measurements

Measurements according to skeletal relationships

The cephalometric radiographic angular and linear measurements used to verify and classify patients according to their skeletal relationships are as follows:

- **SNA angle:** angle formed by SN plane and NA line.²⁰
- **SNB angle:** angle formed by SN plane and NB line.²⁰
- **ANB angle:** difference between SNB angle and SNA angle.²⁰
- **Wits appraisal:** linear measurement taken on the occlusal plane (OP) from a perpendicular line drawn from point A and point B.²¹
- **Facial plane angle:** formed by FH plane and N-Pog line; represents the position of the chin.²⁰
- **Convexity:** linear measurement from point A to line N-Pog.²²

Measurements according to radiographic skeletal morphological features

The measurements used to characterize the radiographic skeletal morphological features of the selected radiographs are the following eight angular measurements and one linear measurement (refer to Figure 2), as per the study by Cangialosi:¹⁷

- **Posterior facial height (PFH):** from sella to gonion.
- **Anterior facial height (AFH):** from nasion to menton.
- **Upper facial height (UFH):** from nasion to the palatal plane.
- **Lower facial height (LFH):** from palatal plane to menton.
- **Sn-GoGn:** angle formed by sella nasion line and mandibular plane.
- **Gonial angle:** angle formed by posterior border of the ramus of the mandible and mandibular plane.
- **SN-PP:** angle formed by nasion line and palatal plane.
- **PP-GoGn:** angle formed by palatal plane and mandibular plane.
- **Open bite:** measured in millimetres.

Figure 2 shows the landmarks, linear and angular measurements that were performed. The values obtained were recorded and entered into a computer for statistical analysis.

To determine the errors associated with the identification and measurement of landmarks, ten radiographs were randomly selected, retraced and re-measured by the principal investigator (intra-examiner reliability) as well as the supervisor (inter-examiner reliability). The Pearson correlation coefficient test was performed to determine intra- and inter-examiner reliability. Arithmetical mean and standard deviations were calculated for all the variables. A Shapiro-Wilk test was carried out to objectively assess the normality of distribution of measured variables.

The mean values for male and female were compared by a two-sample t-test to determine if there were any differences in skeletal features. The mean values obtained from the sample for all nine variables of test groups were compared with the nine variables of the control

group by a one-sample t-test to evaluate any significant variations that characterized skeletal morphology in the open bite malocclusions, according to skeletal relationship.

The level of significance was set at $p \leq 0.05$. All statistical analyses were performed using the statistical analysis system (SAS) 9.2 computer software programme.

RESULTS

The Shapiro-Wilk test revealed that >90% of the variables were normally distributed ($p \geq 0.05$). The intra- and inter-reliability tests showed the correlation coefficient exceeded 0.8, indicating that the method of measurement was reliable and reproducible.

Comparison between male and female control sample

There was no statistically significant difference between the mean values of male and female samples. There was a trend of an insignificantly larger gonial angle in males compared to females.

Comparison of measured variables between control and Class I anterior open bite male sample

A significant difference was found in the mean value of PFH/AFH ratios. In the linear variables, only the LFH showed a trend of being larger in the Class I group compared to the control group, but it was not significant. The Class I group showed a trend of increased angular measurements, although it was not significant. The PFH/AFH ratio was significantly larger in the control group.

Comparison between control and Class II anterior open bite male group

A significant difference was found in the variables LFH, Sn-GoGn, gonial angle, PP-GoGn and PFH/AFH ratio. They were all significantly larger in the Class II group compared to the control group. There was a trend of larger linear and angular values in the Class II male group compared to the control group, although it was not significant.

Comparison between controls and Class III anterior open bite male group

A statistically significant difference was found in the values of all angular variables, except PP-GoGn. All the linear variables, except PFH, and angular variables were larger in the Class III male group compared to the control group, although it was not significant. The control group showed a significantly larger PFH/AFH ratio compared to the Class III group.

Comparison between control and Class I anterior open bite female sample

Three out of nine variables demonstrated a statistically significant difference. The PFH/AFH ratio was significantly smaller in the Class I open bite group compared to the control group. PP-GoGn and Sn-GoGn were significantly larger in Class I compared to the control group.

Comparison between control and Class II anterior open bite female sample

Six of the nine variables demonstrated a statistically significant difference. The mean values of the linear measurements (AFH, UFH and LFH) of the Class II group were significantly larger compared to the control group.

All angular variables, except the Sn-PP and gonial angle, were significantly larger in Class II than in the control group. The PFH/AFH ratio was significantly larger in the control group compared to the Class II female group.

Comparison between control and Class III anterior open bite female sample

UFH and LFH were significantly different in the two groups. There was a trend of larger linear variables (PFH, AFH, UFH and LFH) and gonial angle in the Class III group compared to the control group, but it was not significant. The PFH/AFH ratio of the control group was larger compared to the Class III group, although it was not significant.

Comparison between male and female Class I open bite sample

There was no statistically significant difference in the values of the Class I groups. The female group showed an insignificantly larger AFH compared to the male group.

Comparison between male and female Class II open bite sample

There was no significant difference between male and female in all measured variables, however, there was an insignificant trend of a larger gonial angle in the Class II male group compared to the Class II female group.

Comparison between male and female Class III open bite sample

With the exception of Sn-GoGn, there was no statistically significant difference between the mean values of the male and female samples. The PFH and the PFH/AFH ratio were insignificantly larger in the female group compared to the male group. There was also an insignificant trend of larger Sn-GoGn and gonial angles in the male group compared to the female group.

DISCUSSION

This study sought to determine the skeletal morphological features of patients with AOB malocclusion. The data obtained in this study showed that there are differences between patients with AOB and those without it. These differences were especially notable in the angular measurements as compared to the linear measurements.

There were more females who presented with AOB compared to males in the study period. This could be because females appear to be more willing to seek and receive orthodontic treatment compared to male subjects. The finding is similar to studies done elsewhere.^{23,24}

The total PFH and AFH were found to be smaller in the Class I open bite samples of male and female groups compared to the male and female control groups. These findings are in agreement with the findings by Cangialosi¹⁷ who reported that such a finding may be an indication of the specific area, or areas, responsible for open bite malocclusion.

The increase in AFH is associated with an increase in the LFH caused by downward tipping of the palatal

plane, and/or mandibular plane. Nielsen²⁶ reported that the increase in AFH is apparently as a result of the eruption of maxillary and mandibular posterior teeth and the amount of sutural lowering of the maxilla.

In this study an increase in AFH was noted in the Class II female group with anterior open bite malocclusion compared to the female control group. These results are contrary to those of Horowitz²⁶ who found that males have a 10% increase in total AFH compared to females,

Table 1. Male control and test groups.

Variable	Mean Males Control n=31	Mean Class I Males AOB n=10	p-values	Mean Class II Males AOB n=13	p-values	Mean Class III Males AOB n=11	p-values
PFH (mm)	81.5 <i>11.64</i>	81.8 <i>12.3</i>	0.9592	85.7 <i>12.31</i>	0.2888	81.7 <i>12.88</i>	0.9694
AFH (mm)	133.7 <i>20.25</i>	132.7 <i>16.51</i>	0.8942	143.1 <i>18.80</i>	0.1570	141.7 <i>16.89</i>	0.2483
UFH (mm)	54.8 <i>7.49</i>	55.2 <i>6.58</i>	0.8865	57.5 <i>7.59</i>	0.2940	58.4 <i>6.88</i>	0.1790
LFH (mm)	79.2 <i>12.91</i>	81.0 <i>10.07</i>	0.6776	88.1 <i>12.58</i>	0.0403	85.4 <i>10.53</i>	0.1599
Sn-GoGn (°)	30.1 <i>6.15</i>	34.6 <i>9.09</i>	0.0794	36.5 <i>7.72</i>	0.0059	36.6 <i>6.74</i>	0.0054
Gonial angle (°)	122.8 <i>7.47</i>	125.1 <i>11.02</i>	0.4447	131.1 <i>7.11</i>	0.0013	128.5 <i>5.66</i>	0.0261
SN-PP (°)	5.1 <i>4.11</i>	6.1 <i>2.97</i>	0.4867	4.7 <i>3.81</i>	0.7629	8.2 <i>4.57</i>	0.0441
PP-GoGn (°)	25.0 <i>6.14</i>	28.5 <i>6.75</i>	0.1347	31.8 <i>6.06</i>	0.0017	28.5 <i>7.00</i>	0.1307
PFH: AFH (%)	67.1 <i>4.55</i>	63.4 <i>5.37</i>	0.0390	62.7 <i>4.16</i>	0.0047	60.8 <i>5.39</i>	0.0006

Means in standard print, standard deviations in italics and control groups shaded in blue p≤0.05 significant.

Table 2. Female control and test groups.

Variable	Mean Females Control n=31	Mean Class I Females AOB n=25	p-values	Mean Class II Females AOB n=30	p-values	Mean Class III Females AOB n=30	p-values
PFH (mm)	83.2 <i>10.03</i>	81.6 <i>12.27</i>	0.5932	84.1 <i>13.26</i>	0.7640	86.5 <i>12.60</i>	0.2617
AFH (mm)	133.5 <i>14.00</i>	136.3 <i>18.43</i>	0.5184	144.3 <i>15.61</i>	0.0062	141.1 <i>19.26</i>	0.0824
UFH (mm)	54.1 <i>3.77</i>	53.5 <i>5.91</i>	0.6813	56.9 <i>5.35</i>	0.0213	57.9 <i>7.84</i>	0.0205
LFH (mm)	77.8 <i>8.38</i>	82.4 <i>12.37</i>	0.1203	87.1 <i>10.70</i>	0.0002	84.6 <i>12.28</i>	0.0154
Sn-GoGn (°)	31.0 <i>4.01</i>	34.7 <i>6.65</i>	0.0198	35.9 <i>7.25</i>	0.0021	31.8 <i>5.73</i>	0.5135
Gonial angle (°)	113.0 <i>40.13</i>	124.4 <i>6.54</i>	0.1295	125.7 <i>9.46</i>	0.0969	125.7 <i>7.85</i>	0.0929
SN-PP (°)	5.5 <i>3.83</i>	4.5 <i>3.85</i>	0.3328	5.7 <i>4.13</i>	0.8685	5.4 <i>3.85</i>	0.9592
PP-GoGn (°)	25.5 <i>4.72</i>	30.2 <i>5.58</i>	0.0012	30.3 <i>6.22</i>	0.0013	26.4 <i>5.24</i>	0.4914
PFH: AFH (%)	65.7 <i>3.28</i>	62.0 <i>4.94</i>	0.0016	61.0 <i>5.33</i>	0.0002	63.8 <i>4.86</i>	0.0841

Means in standard print, standard deviations in italics and control groups shaded in blue p≤0.05 significant.

Table 3. Comparison of measured variables between male and female control groups.

Variable	Controls			Class I (AOB)			Class II (AOB)			Class III (AOB)		
	Male	Female	p-value	Male	Female	p-value	Male	Female	p-value	Male	Female	p-value
PFH (mm)	81.5	83.2	0.5518	81.6	81.8	0.9707	84.1	85.7	0.7051	86.5	81.7	0.2903
AFH (mm)	133.7	133.5	0.9693	136.3	132.7	0.5958	144.3	143.1	0.8352	141.1	141.7	0.9305
UFH (mm)	54.8	54.1	0.6084	53.5	55.2	0.4559	56.9	57.5	0.7597	57.9	58.4	0.8565
LFH (mm)	79.2	77.8	0.6268	82.4	81.0	0.7587	87.1	88.1	0.7807	84.6	85.4	0.8504
Sn-GoGn (°)	30.1	31.0	0.4918	34.7	34.6	0.9868	35.9	36.5	0.8345	31.8	36.6	0.0298
Gonial angle (°)	122.8	113.0	0.1926	124.4	125.1	0.8495	125.7	131.1	0.0697	125.7	128.5	0.2932
SN-PP (°)	5.1	5.5	0.6906	4.5	6.1	0.2490	5.7	4.7	0.4709	5.4	8.2	0.0630
PP-GoGn (°)	25.0	25.5	0.7172	30.2	28.5	0.4448	30.3	31.8	0.4685	26.4	28.5	0.3153
PFH: AFH (%)	67.1	65.7	0.1557	62.0	63.4	0.4579	61.0	62.7	0.3027	63.8	60.8	0.1009

p≤0.05 significant.

although the class of malocclusion was not specified in that study.

The Sn-GoGn in this study was significantly greater for the open bite groups of female Class I and II, and male Class II and III malocclusions compared to controls. This means that these open bite subjects demonstrated a more vertical growth pattern and an increase in the total AFH.

The finding is similar to that of Cangialosi¹⁷ and of Nahoum¹⁴ who found an increase in the total AFH in AOB subjects. The increase in Sn-GoGn in subjects with AOB is expected because most etiological factors, for example habits and chronic upper airway obstructions, encourage vertical facial growth.

Similarly, the gonial angle was significantly larger in male Class II and III with AOB as compared to the normal groups. This finding is an indication that in AOB subjects the lower facial height is increased and the subjects presented with increased vertical facial dimensions. Authors such as Sassouni and Nanda², Subtelny and Sakuda,⁶ and Trouten²⁷ also found similar results in the gonial angle of open bite patients.

Class III AOB male subjects were found to have a significantly larger Sn-PP compared to the control group. This shows that the upper AFH was increased in Class III AOB male subjects. This could be a result of the counter-clockwise rotation of the SN or clockwise rotation of the PP.

The other malocclusion groups showed no significant difference from the control groups, meaning that there was no change in the inclination of the PP or SN planes.

These results are in agreement with those reported by Subtelny and Sakuda⁴ and Cangialosi¹⁷ who concluded that the anterior open bite malocclusion was not due to a change in maxillary inclination, but was mainly due to the clockwise rotation/downward opening of the mandibular plane. This finding is in contrast to that of Nahoum¹⁸ and Lopez-Gavito²⁸ who reported an increase in the palatal plane due to the anterior maxillary rotation. The PP-GoGn angle in this study was found to be significantly greater in Class I and Class II female subjects, as well as Class II male subjects, compared to the control groups. This finding could indicate an upward inclination in palatal plane or downward tipping of the mandibular plane. In this study, Sn-GoGn and PP-GoGn showed similar findings, namely significantly larger angles in female Class I and II, and male Class II patients.

Therefore, one could argue that because the Sn-PP was not significant between malocclusions (except for Class III male and female groups) and controls, the increase in the PP-GoGn angle was due to a downward mandibular rotation. These results are similar to those reported by Nahoum¹⁴ and Cangialosi.¹³

In contrast to these findings, Sassouni and Nanda² found a sharply angulated Sn-PP in open bite subjects, which was also found in the Class III male group of the current study.

There was a significant increase in the LFH in Class II male and female and Class III female groups compared to controls. The increase in the LFH signifies an increase in the lower anterior facial dimension in the mentioned malocclusion groups. Similar findings have been reported in other studies.^{1,2,15,17}

Female subjects with Class II and III AOB demonstrated a significant increase in UFH, which is an indication of excess vertical maxillary growth. Such growth patterns have a tendency of rotating the mandible downward and backward leading to the development of an anterior open bite malocclusion. This is in contrast with the findings by Tsang and Cheung,²⁹ Nahoum,¹⁸ Sassouni and Nanda,² and Richardson²⁶ who did not find any difference in the upper anterior facial height in open bite subjects.

The PFH/AFH ratio was significantly smaller in all groups of malocclusion except Class III females, indicating a smaller posterior facial height in open bite malocclusion subjects. A similar result was confirmed in research by Sassouni and Nanda² and Nahoum.¹⁸ This result is expected because most subjects presented with an increase in the LFH.

Except for the Sn-GoGn, there was no significant difference between the mean values of male and female subjects in all groups. On the other hand, there was a significant increase in Sn-GoGn in males Class III compared to females of the same group. This means that male open bite subjects demonstrated a more vertical growth pattern and increased total anterior facial height.

The finding was similar to that found by Cangialosi¹⁷ and Nahoum¹⁸ who found an increase in the total anterior facial height in open bite subjects even though it was not stratified according to gender. Nahoum¹⁸, Fields, Proffit and Nixon,¹⁵ and Hassanali and Pokhariyal³¹ found a larger total facial height in males who have a larger and greater post-pubertal vertical growth spurt than females.¹⁸ Nanda concurred with these findings reporting that this gender dimorphism becomes apparent from the beginning of the growth spurt when boys are about 14 years of age.³²

CONCLUSIONS

The following conclusions were made from this study:

- The anterior facial height is larger in Class II female subjects with AOB.
- The PFH/AFH ratio is less in subjects with anterior open bite malocclusion.
- The UFH of females with Class II and III AOB is larger.
- The LFH of Class II male and female subjects and Class III female subjects with AOB is larger.
- The mandibular plane angle is increased in females with Class I and II AOB, as well as in males with Class II and III AOB.
- The gonial angle is increased in Class II and III male subjects with AOB.
- The palatal plane angle (PP-GoGn) is larger in female Class I and Class II AOB, as well as in Class II male subjects with AOB.

- The vertical position of the maxilla, as represented by the palatal plane (SN-PP), changed only in Class III males with AOB; therefore, it was only in Class III male subjects where anterior open bite malocclusion was due to a change in the maxillary inclination.
- The difference between male and female subjects with anterior open bite is brought about by the difference in the Sn-GoGn which is larger in male than in female subjects.

Black patients with open bite were found to have greater facial height because of their lower facial dimensions, not their upper facial dimensions. This conclusion is supported by Beane, Reimann, Phillips and Tulloch³³ who arrived at the same conclusion.

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