CEPHALOMETRIC PARAMETERS AFFECTING ANTERIOR OPEN BITE

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ABSTRACT

To investigate the parameters that affect the severity of open bite, 111 cephalometric radiographs of open bite subjects were evaluated and compared to 60 cephalometric radiographs of normal controls.

While all the control subjects had Class I molar relationship, the open bite group were 49% Class I, 30% Class II, and 21% Class III.

Significant increase in the means of the following measurements was found in open bite subjects: the total face height, the lower face height, the Y-axis, the gonial angle, the lower occlusal plane angle, and the mandibular plane angle, while significant decrease was found in the total posterior face height, the lower posterior face height, the mandibular body length, the maxillary length, ramus height, facial angle, and interincisal angle.

Parameters that correlated highly with open bite were: lower occlusal plane to SN, mandibular plane to SN, gonial angle, Y-axis, lower anterior face height. Parameters that showed significant inverse correlation with open bite were: ramus height, maxillary length, mandibular length, lower posterior facial height, and total posterior facial height.

INTRODUCTION

Even though open bite (OB) has low incidence rate, it is still a challenging problem facing the orthodontists because of its treatment difficulty and stability rate. Successful diagnosis and treatment modalities should be based on scientific

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knowledge of the morphological, etiological and environmental factors related to the condition. Understanding the associations of dentoskeletal complex is crucial for accurate diagnosis and judgment of the condition and consequently treatment planning and stability.

Anterior open bite studies have aimed to categorize skeletal, dental and facial characteristics of this type of malocclusion. Most subjects in these studies were either Caucasian of European [1,2,3,4,5,6,7] origin or from the Far East (Chinese, Taiwanese);[8,9] in addition to two studies on African Americans [10,11]. Only one study was reported on skeletal and dental characteristics of Saudi Arabian adults [12].

Several reports have studied the skeletal changes in individuals with variations in incisal over lap, open bite or deep bite [2, 3, 4, 7, 8, 17, 23, 24, 25]. Most puplished data on skeletal characteristics of the open bite reported an increase in mandibular plane angle, gonial angle and lower face height [10,7,6,64,28]. However palatal plane angle, cranial base angle, ramus height and posterior face height were more controversial. Some investigators agreed that these measurements are decreased in open bite subjects [2,3,4,7,12,18,19,20], while others have found that those measurements are not changed in open bite cases [3,5,12,13,21,22].

A number of studies have attempted to predict the abnormal facial pattern in growth and development of the dentoskeletal complex. [14,17,23,24,25,26]. In those studies, the strong correlation between mandibular plane, gonial angle, occlusal plane angle and overbite was emphasized. [14,26,27,28,29].

In a study by Schudy, the association of vertical with horizontal growth was identified to have an important effect on overbite and overjet [30]. It was therefore concluded that the condyler growth affects the inclination of mandibular plane angle and thus the tendency of open bite. Further attempt to predict the severity of open bite, Kim stated that the ODI (overbite depth indicator) value demonstrates the highest correlation with open bite.[25] Tsang also found that the lower occlusal plane and the upper posterior dental height had the highest correlation with open bite[27]. Beckmann et at reported the association of open bite with the size and the form of the symphysis, lower face height, and interincisal angle [14]. Others reported a correlation between upper anterior face and lower anterior face growth rate and the overbite. Subjects with open bite tendency showed slow growth in the upper anterior face and fast growth in the lower anterior face [1,17,21].

The purpose of this study is: 1) To characterize the skeletal and dentoalveolar features between open bite and compare them to normal individuals. 2) To identify the skeletal and dentoalveolar parameters that are related to open bite that may enable the clinician to predict open bite tendency thus help in early intervention, and will also helps predict treatment and outcome.

Materials and Method:

The sample consisted of: open bite group (OB), these were111 open bite cases; 58 female and 53 males. The age range was 10 to 17 years. The selection criteria for the open bite group were: the presence of 1 mm or more anterior open bite, no previous orthodontic treatment, no missing teeth, all anterior permanent teeth are fully erupted, no previous trauma to the maxillary complex, no serious illness. The control group (C), matched for age and sex consisted of 60 normal subjects, 30 males and 30 females the age range was 10 to 17, clinically determined as having a normal profile and Class I occlusion, normal overbite, normal overjet, no missing teeth and no previous orthodontic treatment.

Cephalometric landmarks and digitization:

The cephalograms were scanned and digitized using Epson expression 1680 scanner attached to Dell computer using Dolphin imaging Version 8.0 software. The digitization was done by the same investigator. To enhance viewing, the digitizing was done in a dark room. The landmarks and measurements taken for each cephalogram are shown in fig 1,2 and table I.

All measurements were given by the Dolphin imaging program except for Maxillary occlusal plane- SN and Mandibular occlusal plane- SN; these were manually measured using orthodontic protractor.

To minimize digitizing error, 20 randomly selected cephalograms were deigitized by the same investigator six weeks apart; Pearson’s coefficient correlation and standard error of the estimate were calculated to determine any intra-examiner differences.

Statistical Analysis:

SPSS statistical software version 10.0 was used. Standard descriptive analyses of the data were calculated for each skeletal and dental cephalometric measurement. Pearson coefficient was used to determine intra-examiner error. Independent t test was used to evaluate the difference in means between open bite and control subjects. Pearson “r” correlation coefficient was calculated to detect the skeletal and dentoalveolar measurements that are associated with open bite malocclusion.

Table. 1

SKELETAL MEASUREMENTS	
Linear measurements	
Total Face Height (AFH)	N—Me
Upper Anterior Face Height (UAFH)	N—ANS
Lower Anterior Face Height (LAFH)	ANS—Me
Posterior Face Height (PFH)	S—Go
Lower Posterior Face Height (LPFH)	Go—maxillary plane
Upper Posterior Face Height (UPFH)	S—PNS
Mandibular Body Length	Go—Gn
Ramus Height	Ar—Go
Length of the maxilla	ANS—PNS
Angular measurements	
SNA	S—N—A point
SNB	S—N—B point
ANB	A point—N—B point
Facial angle	N—Pg line and Frankfort horizontal line
Cranial Base Angle	N—S—Ba
Y-Axis	N—S—Gn
Mandibular Plane Angle	S—N—GoGn
Occlusal Plane	Max. Occlusal plane—SN Mand. Occlusal plane—SN
Gonial Angle	Ar—Go—Me
Palatal plane Angle	SN—PP PP—Frankfort Horizontal
DENTO-ALVEOLAR MEASUREMENTS	
Linear Measurements	
Upper Posterior Dental Height (UPDH)	Max. mesiobuccal cusp tip of the first molar –PP
Upper Anterior Dental Height (UADH)	Max. incisor tip—PP
Lower Posterior Dental Height (LPDH)	Mand. Mesiobuccal cusp tip of the first molar –PP
Lower Anterior Dental Height (LADH)	Mand. Incisor tip—PP
Upper Incisal Angle (U1-SN)	The angle between SN and the long axis of the upper central incisor.
Inter Incisal Angle (U1-L1)	The angle between the long axis of the upper central incisor and the long axis of the lower mandibular central incisor.
IMPA	The inner angle between the mandibular plane and the long axis of the lower central incisor.

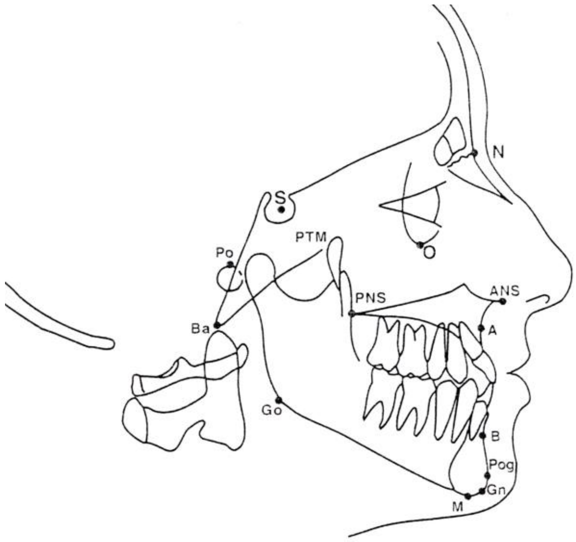

Fig1. Cephalometric skeletal Landmarks.

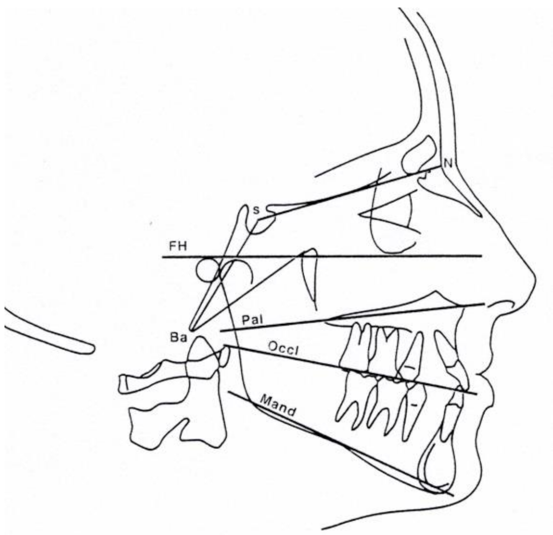

Fig2. Cephalometric Planes

RESULTS

For the error method for digitization, the Pearson's Coefficient ranged from .913 and .996 indicating high correlation between readings for all variables.

Anterior and posterior face heights are presented in table II. Subjects with OB showed significant increase in lower and total anterior face height while they showed significant decrease in lower and total posterior face heights. The upper anterior and posterior face heights showed no significant difference.

Linear and angular skeletal measurements are presented in table III. Subjects with anterior open bite showed significant greater values in: Y axis, mandibular plane angle, goinal angel and lower occlusal plane to SN angle. While they showed significant smaller values in ramus height, mandibular body length, maxillary length and facial angle; the anteriorposterior position of both the maxilla and the mandible represented by SNA and SNB showed significant decrease, but the relation of the maxilla to the mandible,ANB, was normal. The upper anterior and posterior face height, the upper occlusal plane, palatal plane to SN and Frankfort horizontal plane and the saddle angle all showed no significant difference.

The linear and angular dento-alveolar measurements are displayed in table IV**.** No significant difference was found in all linear dento-alveolar measurement, except for the interincisal angle which showed significant decrease and upper incisor to SN plane showed significant increase.

Linear and angular skeletal parameters that were associated with overbite are presented in a stepwise manner in table V; the lower occlusal plane, mandibular plane, Y-Axis, gonial angle, and lower anterior face height showed the highest inverse correlation with overbite (pearson r = -0.526 to -0.304) the AFH showed the least significant (r = -0.191). Maxillary length, SNB, SNA, facial angle, the mandibular body length, lower and total posterior face height and ramus height showed significant direct correlation with overbite (r = .364 and r = .203). Interincisal angle showed significant direct correlation with overbite and upper incisor to SN line showed significant inverse correlation (r =.385 and r = -.167 respectively).

The upper anterior dental height and lower posterior dental height showed significant correlation with lower occlusal plane ($P \leq 0.01$ and $P \leq 0.05$ respectively). The upper anterior dental height and lower anterior dental height showed significant correlation with mandibular plane ($P \leq 0.01$ and $P \leq 0.05$ respectively).

DISCUSSION

The purpose of the present study was to identify the skeletal and dental characteristics of open bite and the possible predictors that are associated with OB in a sample of Saudi population, although they are likely to be similar to other populations, it was important to establish this valuable information. The results of the present study strongly show a distinct skeletal pattern for open bite subjects represented in the significant increase in gonial angle and Y-axis, and the significant decrease in facial angle and the anteroposterior position of the maxilla and the mandible. These results are in agreement with several other studies (3,5,6,8,19,31,32). The forementioned measurements also affected the rotation of the mandible leading to increase in the both mandibular plane and lower occlusal plane angles which is a significant result of the present study and is in agreement with Nahoum (1,19,35), Subtenly & Sakuda (3) and several other studies (8,9,31,32,33). However Nanda (21,34) did not find the gonial angle and the occlusal plane angle to differ from the control.

Table II. Comparison of Upper & Lower Facial Heights between open bite (OB) and control (C) subjects:

Measurements	group	N	Mean	SD	t value
AFH	OB	111	122.95	8.36	
	C	60	119.31	8.62	2.667**
UAFH	OB	111	52.43	4.04	
	C	60	52.41	4.10	.034
LAFH	OB	111	72.67	6.14	
	C	60	69.15	5.87	3.67***
PFH	OB	111	71.36	6.91	
	C	60	73.99	7.43	-2.26*
LPFH	OB	111	27.84	5.50	
	C	60	30.14	5.65	-2.56**
UPFH	OB	111	43.50	4.01	
	C	60	43.84	3.54	-.56

* Significant at 0.05 ** Significant at 0.01 *** Significant at 0.001

Table III. Comparison of Angular & Linear Skeletal measurements between open bite (OB) and control (C) subjects:

Measurements	group	N	Mean	SD	T value
Angular Measurements					
SNA	OB C	111 60	80.50 83.19	4.87 4.21	-3.76***
SNB	OB C	111 60	76.77 79.75	4.99 3.63	-4.46***
ANB	OB C	111 60	3.82 3.44	2.94 2.13	.97
FACIAL ANGLE	OB C	111 60	79.06 81.49	4.66 4.23	-3.46***
NS-Ba	OB C	111 60	130.77 129.31	5.61 4.98	1.75
Y-Axis	OB C	111 60	71.39 67.40	5.18 3.73	5.78***
NS-GoGn	OB C	111 60	43.26 36.33	6.76 5.21	7.45***
GONIAL ANGLE	OB C	111 60	132.96 126.71	7.37 8.32	4.87***
Uocc-SN	OB C	111 60	16.19 15.48	5.73 4.77	.866
Locc-SN	OB C	111 60	20.91 15.47	5.85 4.77	6.54***
PP-SN	OB C	111 60	7.04 6.44	3.64 2.75	1.37
PP-FH	OB C	111 60	4.94 5.01	4.59 4.37	.028
Linear Measurements					
Mand. b. Length	OB C	111 60	81.74 84.47	8.44 7.14	-2.23*
Ramus Height	OB C	111 60	39.54 41.29	4.86 5.78	-1.99*
Max Length	OB C	111 60	49.81 52.51	4.37 4.06	-4.04***

* Significant at 0.05   *** Significant at 0.001

Table IV. Comparison of Linear and Angular Dento-Alveolar measurements between open bite (OB) and control (C) subjects:

Measurements	group	N	Mean	S D	t value
Linear measurements					
UPDH	OB	111	23.64	3.82	
	C	60	23.11	2.02	.98
UADH	OB	111	28.83	3.74	
	C	60	29.40	3.11	-1.04
LPDH	OB	111	31.63	3.62	
	C	60	30.73	3.48	1.58
LADH	OB	111	42.82	3.95	
	C	60	42.22	3.31	1.05
OVERJET	OB	111	3.66	3.02	
	C	60	3.31	.87	1.13
OVERBITE	OB	111	-3.50	1.83	
	C	60	1.14	.73	-23.47***
Angular measurements					
U1-L1	OB	111	113.21	9.53	
	C	60	121.77	5.69	7.33***
U1-SN	OB	111	111.65	6.19	
	C	60	109.08	5.62	2.74**
L1-MP	OB	111	95.33	7.59	
	C	60	96.51	6.03	-1.17

** Significant at 0.01 *** Significant at 0.001

Table 5. Pearson's correlation coefficients between Linear & Angular Skeletal measurements & Over Bite measurements:

	Linear Skeletal Measurements	Pearson correlation coefficients	Angular Skeletal Measurements	Pearson correlation coefficients
1	MAX. LENGTH	.364**	Locc-SN	-.526**
2	LAFH	-.304**	NS-GOGN	-.520**
3	MAND. B. LENGTH	.241**	Y.AXIS	-.447**
4	LPFH	.222**	GONIAL ANGLE	-.417**
5	PFH	210*	SNB	.358**
6	RAMUS HEIGHT	.203**	SNA	.303**
7	AFH	-.191*	FACIAL ANGLE	.266**

* correlation is significant at the 0.05 level ** correlation is significant at the 0.01 level

When facial heights were compared the lower and total anterior heights showed significant increase in open bite subjects, while the lower and total posterior height showed significant decrease, these results are in accordance with Lopez-Gavito[18], Nahoum[19] and several other studies in the literature [2,3,12,22,24,36,38].

The anterior and posterior dental height showed no significant changes between open bite and control, this result is in agreement with several investigators [28,36,38] but in disagreement with others [2,8,18,20,21,32,33].

Although several studies have compared characteristics of subjects with open bite to those with normal occlusion in various populations, however, only few studies evaluated the correlation between skeletal and dental features of open bite and the possible parameters, that could correlate with the severity of the condition [14,25,27,39,40]. This may enable the clinicians to early diagnose OB tendency and thus increase the ability to treat and plan open bite cases.

In the present sample of Saudi subjects the major area of deformity was found to be mainly in the mandibular skeletal features. The mandibular plane angle, the lower occlusal plane angle, gonial angle and Y-axis showed the highest inverse correlation with overbite; however the ramus height was directly correlated with overbite (table V).

Numerous studies measured the occlusal plane by bisecting the open bite [4,17,37,41,42] however this was rejected by Tsang et al [27] who think that the occlusal plane in OB should be considered differently than non OB subjects, and that bisecting the open bite will give wrong conclusions, so it was important in evaluating the occlusal plane to consider separate upper and lower occlusal planes. The results of the present study supported the concept proposed by Nahoum [19] and Tsang [27] showing that only the lower occlusal plane correlated highly with overbite. Furthermore when the lower occlusal plane and the mandibular plane angle were correlated with upper and lower dental heights, the mandibular plane showed direct significant correlation with the lower anterior dental height ($P \leq 0.05$); and the upper anterior dental height at ($P \leq 0.01$), while the lower occlusal plane showed direct significant correlation with the lower posterior dental height ($P \leq 0.05$); and upper anterior dental height ($P \leq 0.01$). This compensatory mechanism of posterior and anterior teeth indicates that the control of the molar heights during treatment is critical, and that the use of vertical elastics to close the open bite should be limited as stated by Subtenly [3] and Nahoum.[19]

The high correlation between Y-Axis and gonial angle with overbite, may also direct the treatment towards the use of high pull headgears for better control of the molars height. The intrusion of the molars will improve mandibular rotation, which will help in the correction of the chin retrusiveness and thus reduce lower anterior face height.

The significant inverse correlation of lower facial height with over bite indicates that patients having hyperdivergent facial form have a higher tendency toward open bite malocclusion. Many investigators agreed that the increase in the lower third of the face is due to clock wise rotation of the mandible and this is directly associated with open bite [3,5,7,8,12,13,22,36]. Studies from literature showed more controversial results regarding lower posterior face height. While some investigators agree of the direct association of open bite and the decrease in the lower posterior facial heights [3,8,12,20,29], others do not confirm these results [5,21]. The former two predictors (LAFH, LPFH) are important signs of vertical dysplasia and a quick way to help the clinician to evaluate vertical disproportion [5,41].

The present study results showed upper incisor inclination to SN to be significantly inversely correlated with overbite, hence the interincisal angle were found to be directly correlated. The upper incisor inclination showed significant increase when OB subjects were compared with controls and the interincisal angle showed significant decrease (tableIV). These results are in agreement with Ellis & McNamara [2,32], Lopez-Gavito [18] and several other studies [7,8,10,12,36]. The forementoined pattern, increase in upper incisor inclination, and the decrease in lower incisor inclination (not statistically significant) and interincisal angle might represent an abnormal swallowing habit in the present sample pushing against the upper teeth and folding over the lower teeth as also reported by Strab [43] and Hapak. [36]

Further investigation on the etiology and treatment modalities of open bite is important to give us more understanding of the condition and enable us to early diagnose and efficiently treat this difficult malocclusion.

CONCLUSION

The findings of the present study strongly indicate the presence of certain indicators or parameters that relate to open bite: 1) As the lower occlusal plane and mandibular plane become steeper the overbite becomes shallower and the severity of the open bite is expected to increase. 2) The vertical direction of growth of the mandible will lead to an increase in the gonial angle and thus an increase in the mandibular plane steepness and the anterior lower face height. 3) As the ramus height and, posterior facial height decreases the open bite increases. 4) Also as the maxillary length and mandibular body length shortens the open bite tends to increase.

The increase in the gonial angle, lower anterior face height, the mandibular plane and lower occlusal plane angle, also the decrease in the facial angle, lower posterior face height and the anteriorposterior position of the maxilla and mandible all confirm the results of previous studies that open bite malocclusion might be the result in alteration in the skeletal balance of the maxillofacial complex related more to the mandible and its relationships.

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