The morphologic structure of the openbite in adult Taiwanese

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Anterior openbite (AOB), one of the most difficult orthodontic problems to correct, is the absence of contact between the maxillary and mandibular incisors in centric relation.[1] A dental openbite is limited to the anterior region in an individual with good facial proportions.[2] A skeletal openbite, on the other hand, typically involves increased anterior facial height, a steep mandibular plane, and excessive eruption of the posterior teeth.[3] Banks[4] divided skeletal openbite patients into two groups: those with a complete overbite and those with an incomplete overbite. The latter, also called pseudo openbite, is characterized by craniofacial skeletal patterns that differ from normal patterns, especially in the vertical direction.

Cephalometry has been used in dentistry to evaluate orthodontic treatment and describe facial growth. There are many cephalometric analyses available, including the quadrilateral analysis. Introduced by DiPaolo,[5] quadrilateral analysis describes the skeletal configurations of an individual subject's dentofacial complex in both the horizontal and vertical dimensions, regardless of the dentoalveolar relationship. Different facial types can be categorized with this method, including hyperdivergent, hypodivergent, and normal patterns. Each of these divisions encompasses all classifications of the malocclusion as defined by Angle. According to the quadrilateral analysis, a good

Abstract

Anterior openbite (AOB) is an intricate occlusal problem. Treatment of AOB is one of the most challenging tasks in orthodontics. An ethnic-specific norm for craniofacial skeletal patterns would be valuable in diagnosing and treating patients with AOB. To establish this norm for the people of Taiwan, a cephalometric study was conducted using the quadrilateral analysis developed by DiPaolo. The sample consisted of 15 males and 25 females in their 20s and 30s. The patients were randomly selected and were diagnosed with AOB. Various craniofacial skeletal patterns were measured, and these measurements were compared with values taken from a group of normal Taiwanese as well as with published values from a hyperdivergent group of westerners. The results support the following generalizations: (1) The growth pattern of subjects in the AOB group is hyperdivergent. (2) Both the maxillary and mandibular corpora of subjects with AOB are shorter than those of normal subjects. (3) The sagittal angle, average lower facial height, and the maxillary and mandibular sagittal ratio of subjects with AOB are larger than those of normal subjects. Abnormalities in the maxillomandibular complex causing changes in the vertical dimension of facial patterns are involved in AOB.

Key Words

Anterior openbite • Adult Taiwanese • Quadrilateral analysis

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Figure 1
Quadrilateral cephalometric analysis landmarks.

Points
A: Subspinale; B: Supramentale; PTM: Pterygomaxillary fissure; J: Distal limit of mandibular corpus length; A': Projecting a perpendicular from point A; B': Projecting a prependicular from point B; C': Projecting a perpendicular from point PTM; D': Projecting a perpendicular from point J; SG: Intersection of palatal plane and mandibular plane

Lines
A'-C': Maxillary corpus length (Max-L); B'-D': Mandibular corpus length (Man-L); A'-B': Anterior lower facial height (ALFH); C'-D': Posterior lower facial height (PLFH); N-A': Anterior upper facial height (AUFH); SG-C': Posterior leg of maxillary length (PMax); SG-D': Posterior leg of mandibular length (PMan)

Angles
Sagittal angle: Vertex formed by maxillary and mandibular posterior leg; Upper facial angle: Vertex formed by NA' line and palatal plane; Facial angle: Angle formed by NA'B'.

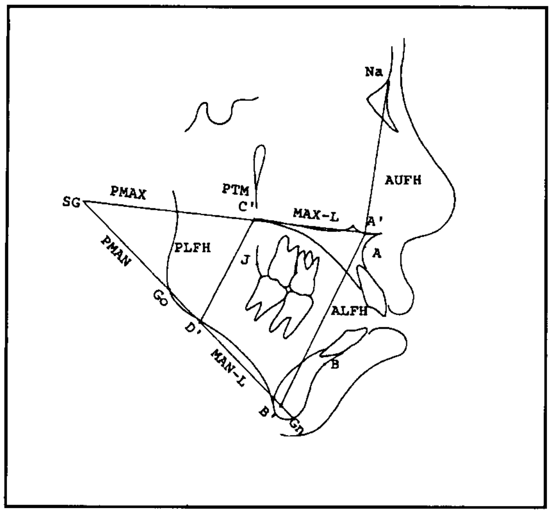

Figure 1

facial pattern shows one-to-one proportionality between maxillary length and mandibular length, and the average of the anterior and posterior lower facial heights equals the denture base length. The acceptable discrepancy between these measurements is 1.5 mm. Through the years, quadrilateral analysis has proven to be a valuable cephalometric tool in diagnosis and treatment planning for orthodontic problems.[6]

When dealing with an orthodontic patient, the clinician should begin the diagnostic process by looking for any skeletal problems.[7] Although an openbite malocclusion may have many etiologic factors,[8-13] one important component is the subject's craniofacial pattern: is the openbite dental or skeletal? The craniofacial pattern of an AOB patient may result from complicated pathogenetic mechanisms or imbalanced or inadequate growth factors. There is, however, no widely accepted method for determining the presence of an openbite tendency.[14] Few researchers have used individualized analyses to discuss craniofacial patterns of openbite. Hence, the purpose of this study was to establish a population norm of craniofacial patterns for AOB patients, which is of potential use in differential diagnosis and treatment planning for orthodontic patients.

Materials and methods

Sample

The sample was selected randomly from private dental clinics. Pretreatment lateral cephalometric radiographs were obtained for 40 subjects, 15 males and 25 females, over 20 years of age, at Chung Shan Medical and Dental College Hospital. The criteria of diagnosis was a negative overbite depth (< 0 mm).

X-ray films were traced, and landmarks were identified using the quadrilateral analysis method[5] and Kim's ODI measurement.[15] To avoid interoperator error, all cephalometric landmarks were identified by one trained dentist and checked by a second investigator to verify the accuracy of the tracing.

Cephalometric landmarks

The landmarks used in this study follow those used by DiPaolo[5] (Figure 1). If the landmarks were bilateral and did not coincide with each other on the tracing, the midpoint was chosen.

1. Maxillary denture base length (maxillary corpus length, maxillary bony arch length, or Max-L): Horizontal linear measurement from the projected perpendicular to palatal plane from pterygoid maxillary fissure (PTM) and point A.
2. Mandibular denture base length (mandibular corpus length, mandibular body arch length, or Man-L): Horizontal linear measurement from the projected perpendicular to palatal plane from point J and point B.
3. Point J: Distal limit of mandibular corpus length.
4. Anterior lower facial height, or ALFH: Vertical linear measurement form anterior limit of maxillary corpus to anterior limit of mandibular corpus.
5. Posterior lower facial height, or PLFH: Vertical linear measurement from posterior limit of maxillary corpus to posterior limit of mandibular corpus.
6. Anterior upper facial height, or AUFH: Vertical linear measurement form anterior limit of maxillary corpus projected on palatal plane from nasion.
7. Maxillary and mandibular posterior legs, or P-Max and P-Man: Posterior extension of corpus length. It determines if there is any sagittal malrelation of the mandibular corpus to the maxillary corpus.
8. Sagittal angle, or Sag-Ang: Vertex formed by the maxillary and mandibular posterior legs.
9. Sagittal ratio: A mathematical expression that identifies and locates the angular, vertical and sagittal relation of the maxillary corpus to the mandibular corpus.
10. Lower facial ratio, or PLFH/ALFH: A mathematical expression that relates posterior lower facial height to anterior lower facial height.
11. Palatal plane to anterior upper facial angle, or UFA: Angle formed by the palatal

plane and the anterior upper facial height. It relates the position of the anterior limits of the maxillary corpus to the position of nasion.

12. Angle of the facial convexity, or facial convex angle, FA: Formed by combining the palatal plane to anterior lower face angle and palatal plane to anterior upper face angle. It gives a skeletal profile assessment.

Skeletal measurements

The following skeletal measurements were made:

1. Maxillary and mandibular arch lengths (corpus length) were located and measured.
2. A line was drawn connecting anterior points of the maxillary and mandibular arches (lower anterior facial height).
3. Another line was drawn connecting posterior points of the maxillary and mandibular arches (lower posterior facial height).
4. A third line connected sella to nasion.
5. A final line connected nasion and the anterior point of the maxillary arch (anterior superior point of quadrilateral).
6. Anterior and posterior facial heights were averaged.
7. Anterior upper facial height was measured.
8. Any deficiencies or excesses on the lower face, either horizontal and vertical, were located.
9. A template was used to check the angle of facial convexity and the ratio of the average of upper to lower face heights.

Statistical analysis

Statistical calculations performed included means, standard deviations, t-test, and correlation and regression analyses by SAS compact software.

Results

Findings from the present study and norms established by Tseng[16] are presented in Tables 1 and 2. Measurements for males and females in the openbite group are shown in Table 3.

In this study, the craniofacial patterns were hyperdivergent. Taiwanese males and females are compared with a hyperdivergent western group in Table 4.

Correlation analysis

All measurements were tested against each other to find patterns of correlation analysis. The correlations among all measurements ranged in absolute value from 0.000 to 0.975. The results are shown in Table 5. The correlation analysis of various proportional measurements is shown in Table 6.

Table 1
Quadrilateral analysis between normal and openbite

	Taiwanese Normal Male (30)		Openbite Male (15)		
	Mean	SD	Mean	SD	t-Value
Max-L	52.64	1.86	46.23	3.2	-8.54 *
Man-L	52.45	1.59	49.00	2.45	-5.7 *
ALFH	70.84	4.30	73.27	9.88	1.16
PLFH	50.27	3.87	52.00	10.34	0.82
Sag-Ang	22.67	3.41	31.53	4.10	7.68 *
PLFH/ALFH	1.41	0.07	1.49	0.26	1.59
AUFH/TFH	46.03	2.43%	43.06	2.01%	-4.08 *
(ALFH+PLFH)/2	60.56	3.8	99.27	11.48	16.87 *
FA	166.43	3.21	172.60	5.19	4.92 *
AUFH	60.40	3.57	57.93	2.66	-2.37 *
(Max-L+P-Max)/P-Max	1.42	0.07	1.54	0.03	6.32 *
(Man-L+P-Man)/P-Man	1.41	0.07	1.54	0.03	6.85 *
P-Max			87.07	14.4	
P-Man			93.40	16.16	
PFH/TFH			0.61	0.04	
ALFH/TFH			0.54	0.06	
Max-L/Man-L			0.95	0.07	
Max-L/average LFH			0.53	0.07	
P-Max/P-Man			0.93	0.05	
TFH			134.8	8.72	
PFH			82.47	8.36	

*Statistically significant at p<0.05

Table 2
Quadrilateral analysis between normal and openbite

	Taiwanese Normal Female (21)		Openbite Female (25)		
	Mean	SD	Mean	SD	t-Value
Max-L	51.84	1.48	46.00	3.03	-8.05 *
Man-L	51.59	1.39	46.88	4.28	-4.83 *
ALFH	66.18	3.50	70.56	7.55	2.34 *
PLFH	46.55	3.87	46.76	6.94	0.12
Sag-Ang	21.84	3.06	32.48	6.29	7.07 *
ALFH/PLFH	1.43	0.08	1.54	0.22	2.17*
AUFH/TFH	46.37	1.49%	43.71	1.49%	-5.41 *
(ALFH+PLFH)/2	56.36	3.43	58.66	7.70	20.68 *
FA	167.93	3.42	169.36	7.04	0.85
AUFH	57.18	2.40	55.88	2.77	-1.68
(Max-L+P-Max)/P-Max	1.43	0.07	1.59	0.05	9.02 *
(Man-L+P-Man)/P-Man	1.42	0.07	1.56	0.05	7.89 *
P-Max			80.48	19.23	
P-Man			85.08	19.51	
PFH/TFH			0.59	0.04	
ALFH/TFH			0.55	0.05	
Max-L/Man-L			0.99	0.09	
Max-L/average LFH			0.56	0.05	
p-Max/P-Man			0.95	0.04	
TFH			127.92	6.17	
PFH			75.96	5.86	

*Statistically significant at P<0.05

Table 3
Quadrilateral analysis between normal and openbite

	Taiwanese Openbite					
	Male (15)		Female (25)			
	Mean	SD	Mean	SD	t-Value	
Max-L	46.23	3.2	46.00	3.03	0.26	
Man-L	49.00	2.45	46.88	4.28	1.99	
ALFH	73.27	9.88	70.56	7.55	0.91	
PLFH	52.00	10.34	46.76	6.94	1.74	
Sag-Ang	31.53	4.10	32.48	6.29	-0.58	
ALFH/PLFH	1.49	0.26	1.54	0.22	0.73	
AUFH/TFH	43.06	2.01%	43.71	1.49%	-1.04	
(ALFH+PLFH)/2	62.64	11.48	58.26	7.70	1.59	
FA	172.60	5.19	169.36	7.04	1.67	
AUFH	57.93	2.66	55.88	2.77	2.33	*
(Max-L+P-Max)/P-Max	1.54	0.03	1.59	0.05	1.59	
(Man-L+P-Man)/P-Man	1.54	0.03	1.56	0.05	1.02	
P-Max	87.07	14.4	80.48	19.23	1.23	
P-Man	93.40	16.16	85.08	19.51	1.46	
PFH/TFH	0.61	0.04	0.59	0.04	1.29	
ALFH/TFH	0.54	0.06	0.55	0.05	-0.5	
Max-L/Man-L	0.95	0.07	0.99	0.09	-1.6	
Max-L/average LFH	0.53	0.07	0.56	0.05	-1.56	
P-Max/P-Man	0.93	0.05	0.95	0.04	-0.75	
TFH	134.8	8.72	127.92	6.17	2.68	*
PFH	82.47	8.36	75.96	5.86	2.65	*

*Statistically significant at P<0.05

Regression analysis

The regression equations and R-square values were obtained by selecting the significant correlated measurements and using the simple regression analysis (Tables 7 and 8). There are two regression equations in Table 7 and six in Table 8 for which the R-square value is larger than 0.60. The equation P-Max=1.04 + 0.93 P-Man can be used to explain the maxillomandibular structure of AOB in 95% of openbite cases (P=0.0001), and the equation M3= 3.76 + 0.92 M4 can be used to explain the structural relation of AOB in up to 91% (P=0.0001).

Discussion

The most significant finding of this study is that the facial patterns of the AOB patients fall exclusively in the category of hyperdivergent, regardless of what class of Angle malocclusion the subject has. In male subjects, when compared with the western hyperdivergent group,[20] the maxillary length is less and the posterior lower facial height greater. The Taiwanese openbite patients had larger posterior facial heights than their counterparts in the West. In addition, the vertical sagittal ratio of Taiwanese AOB patients is smaller than that of the western sample. However, both the average lower facial height and the facial angle measurements are greater in the Taiwanese. The lower face, the maxillomandibular complex, and the sagittal angle were similar in the Taiwan AOB patients and the western hyperdivergent group. It appears that, although subjects of both groups have similar hyperdivergent facial patterns, some differences between the two groups exist, the most notable being the vertical length discrepancy.

When compared with subjects in the normal group, AOB patients have smaller maxillary and mandibular corpus lengths and larger average lower facial heights than the normal group. In openbite cases, lower facial patterns have greater individual variation. In a posteroanterior cephalometric study of openbite, Toutountzakis[17] found that lower facial heights were significantly larger in both males and females. In Huang's[18] study on long-face syndrome in Chinese, facial height was increased by anterior lower facial growth, which in turn was caused by maxillary molar overgrowth. Sagittal angle measurements are greater in both male and female long-face patients than in normal subjects, while the ratio of anterior upper facial height to total facial height is smaller than normal. This may be due to the increase in lower facial height. The sagittal ratio of the maxilla to the mandible is larger than normal (P<0.05). The posterior legs of the maxilla and mandible are smaller than normal. In AOB patients, the lower facial pattern is shorter in the corpus area and longer in the posterior leg.

In general, the vertical length of the facial skeleton is greater in males than in females. In Tseng's[16] study, the normal group showed that there were sex differences in upper anterior facial height, lower anterior facial height, and lower posterior facial height. In our study of AOB patients, several morphological differences distinguished males and females, including upper anterior facial height, total facial height, and posterior facial height. All of these measurements were greater in males than in females. The other measurements in our study showed no sex difference. Our observations are consistent with Rak's[19] investigation.

Wardlaw[21] showed that the overbite depth indicator (ODI) is the most valuable parameter in diagnosing openbite tendency. In correlation analysis, the maxillary corpus length, total facial height, sagittal angle, posterior leg of the maxilla, upper facial angle, and facial angle

Table 4
Quadrilateral analysis of openbite between Taiwanese openbite and Western hyperdivergent

	Taiwanese openbite Male (15)			Western hyperdivergent (64)		Taiwanese openbite Female (25)		
	Mean	SD	t-value	Mean	SD	Mean	SD	t value
Max-L	46.23	3.2	-3.79*	49.4	2.5	46.00	3.03	-4.90
Man-L	49.00	2.45	-0.93	49.6	2.2	46.88	4.28	-3.94*
ALFH	73.27	9.88	1.92	70.3	3.7	70.56	7.55	0.22
PLFH	52.00	10.34	6.94*	42.3	2.3	46.76	6.94	4.57*
Sag-Ang	31.53	4.10	-0.09	31.6	2.2	32.48	6.29	0.98
ALFH/PLFH	1.49	0.26	-4.29*	1.66	0.2	1.54	0.22	-2.08*
AUFH/TFH	43.06	2.01%				43.71	1.49%	
		1:1.85			1:1.34		1:1.82	
(ALFH+PLFH)/2	62.64	11.48	26.97*	56.3	2.9	58.66	7.70	33.4*
FA	172.60	5.19	8.94*	163.8	2.9	169.36	7.04	5.30*
AUFH	57.93	2.66				55.88	2.77	
(Max-L+P-Max)/P-Max	0.65	0.03				0.63	0.05	
(Man-L+P-Man)/P-Man	0.65	0.03				0.64	0.05	
ALFH/TFH	0.54	0.06				0.55	0.05	
Max-L/Man-L	0.95	0.07	1.78			0.99	0.09	0.18
		1:1.05			1:1.01		1:1.01	
Max-L/average LFH	0.53	0.07				0.56	0.05	
		1:1.71			1:1.66		1:1.79	
Sag Ratio	1.49	0.26	-1.35	1.55	0.12	1.54	0.22	-0.27

*Statistically significant at P<0.05

Table 5
Simple correlation analysis

ODI	Max-L 0.53163***	TFH -0.37505*	Sag-Ang -0.41504**	P-Max 0.41280**	UFA -0.52339***	FA -0.55313***
Max-L	Man-L 0.36036*	PMax 0.45616**	PMan 0.42075	UFA -0.33973*		
Man-L	PFH 0.47950	FA 0.39639**				
UFH	TFH 0.69552***	PLFH 0.37739*	PFH 0.41845**	FA 0.31630*		
TFH	Man-L 0.34108*	ALFH 0.64050***	PLFH 0.49966***	PFH 0.68892***	FA 0.34427*	
ALFH	PFH 0.47425**	Sag-Ang 0.33134*				
PLFH	P-Max 0.5007***	P-Man 0.59338***				
Sag-Ang	P-Max -0.78027***	P-Man -0.77366***	PFH -0.32240*			
PFH	P-Max 0.64693***	P-Man 0.67630***	FA 0.35948*			
P-Max	P-Man 0.97544***					
UFA	FA 0.50658***					

*Statistically significant at P<0.05; **Statistically significant at P<0.01; ***Statistically significant at P<0.001

Table 6
Correlation analysis of relative factors in openbite malocclusion

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
M1															
M2															
M3		0.33**													
M4	0.50*	0.55***	0.96***												
M5		0.33*		0.35*											
M6	0.48**		0.99***	0.89***											
M7	0.38*		0.96***	0.82***		0.88***									
M8	-0.66***														
M9	-0.80***	0.31*						0.59***							
M10	-0.69***	0.49**					-0.43**	0.46**	0.72***						
M11	0.35*	0.43**	0.77***	0.77***		0.72***	0.62***								
M12		-0.34*	-0.47**	-0.56***	-0.96***	-0.41**	-0.49**				-0.37*				
M13		0.33*	0.36*						0.54***	0.36*					
M14			0.47**				0.40*		0.38*						
M15	0.78***	0.39*	0.61***	0.72***		0.66***	0.48**	-0.44**	-0.54***	0.34*	0.76***				

M1 = (ALFH+PLFH)/2; M2=(Max-L+Man-L)/2; M3=PMax+Max-L; M4=PMan+Man-L; M5=PLFH/ALFH; M6=P-Max/(PMax+Max-L); M7=PMan/(PMan+Man-L); M8=UFH/TFH; M9=Max-L/M1; M10=Man-L/M1; M11=PFH/TFH; M12=ALFH/PFLH; M13=Sag-Ang; M14=ODI; M15=PFH
*Statistically significant at P<0.05; **Statistically significant at P<0.01; **Statistically significant at P<0.001

do have a higher correlation with significant ODI difference at P<0.01. In Kim's analysis, the smaller the ODI, the higher the tendency for openbite. The mandibular plane angle sometimes replaces the sagittal angle in long face analysis. Correlation analysis shows a negative correlation between ODI and sagittal angle. An openbite tendency might exist when the sagittal angle is large, the ODI value is small, the lower facial height is large, and the maxillomandibular complex growth is in a clockwise direction.

Our results show that the sagittal angle has a negative correlation with the posterior leg of maxilla and mandible (P<0.01) and posterior facial height (P<0.05). This demonstrates that the sagittal angle of openbite is larger and the posterior legs of the maxilla and mandible as well as the total facial height are smaller. Maxillary and mandibular sagittal ratios are larger in the openbite group (Figure 2).

Correlation analysis of the openbite group shows that ODI is smaller, sagittal angle is larger, posterior legs of the maxilla and mandible are smaller, and maxillary and mandibular sagittal ratios are larger. All these measurements correlate significantly and can therefore be used as references in diagnosing openbite tendency.

In relative proportional correlation analysis (Table 6), as average lower facial height increases, so do the maxillary sagittal ratio, mandibular sagittal ratio, PFH/TFH, and posterior facial height. But UFH/TFH and the ratio of maxillary and mandibular corpus length over average LFH, vertical sagittal ratio will decrease. When posterior facial height/total facial height (PLFH/TFH) ratio increases, the sagittal angle and posterior facial height also increase (P<0.01). Correlation analyses show that the openbite facial pattern in vertical height is abnormal.

Total mandibular length and total maxillary length have the strongest correlation in openbite analysis. Total mandibular length correlates with average lower facial height. The total length of maxilla correlates positively (P=0.0021) with ODI, that is, when ODI is small, total maxillary length is short. Table 1 shows maxillary corpus length in openbite patients is shorter than the normal maxillary corpus length. It appears that the posterior leg of the maxilla in the openbite group is shorter than in the normal group. The results show that the maxillary structure of openbite is also abnormal.

Both maxillary and mandibular sagittal ratios are correlated with average lower facial height. In openbite patients, both maxillary and mandibular sagittal ratios increase and so does the average lower facial height. However, the maxillary and mandibular corpus lengths are short. The length of the posterior legs of the maxilla and mandible are smaller than in the normal group. The UFH/TFH ratio correlates negatively (P=0.0042) with posterior fa-

Table 7
Equations of significant correlation measurements analyzed by regression method

	R square	t value
ODI=163.24-0.57FA	0.3059	-4.093
ODI=53.21+0.16P-Max	0.1779	2.868
UFH=23.51+0.25FH	0.4833	5.962
TFH=87.88+0.60ALFH	0.4102	5.141
TFH=108.29+0.46PLFH	0.2497	3.556
TFH=59.69+0.42FA	0.1185	2.26
Max-L=39.56+0.08PMax	0.2081	3.16
Max-L=32.32+0.29Man-L	0.1298	2.381
Man-L=56.12-0.31Sag-Ang	0.3195	-4.224
Man-L=28.62+0.24PFH	0.2299	3.386
Man-L=8.31+0.23FA	0.1571	2.662
AUFH=29.59+0.54PFH	0.2249	3.321
ALFH=55.27+0.51Sag-Ang	0.1098	2.165
PLFH=28.45+0.25PMax	0.2502	3.561
PLFH=24.37+0.28PMan	0.3521	4.544
Sag-Ang=52.39-0.25PMax	0.6088	-7.69
Sag-Ang=79.35-1.02Max-L	0.3195	-4.224
Sag-Ang=50.75-0.24PFH	0.1038	-2.09
PFH=54.28+0.27PMan	0.4574	5.66
PMax=1.04+0.93PMan	0.9515	27.299
UFA=39.54+0.29FA	0.2566	3.622

All equations statistically significant at P<0.001

Table 8
Equation of significant correlation measurements analyzed by regression method

	R square	t value
M1=102.75-55.08M9	0.6389	-8.2
M1=39.65+0.15M4	0.2472	3.52
M1=27.66+50.46M7	0.145	1.256
M1=28.60+31.04M10	0.0482	1.256
M1=10.66+0.63M15	0.612	1.661
M2=36.93+0.08M3	0.2747	3.794
M2=36.30+0.08M4	0.3009	4.044
M2=39.09+10.08M9	0.0976	2.027
M2=32.49+14.17M10	0.0458	1.35
M2=29.07+29.67M11	0.1841	2.928
M2=54.66-0.24M13	0.2228	-3.3
M2=35.23+0.15M15	0.1549	2.639
M3=3.76+0.92M4	0.9128	19.947
M3=185.69-37.67M12	0.2191	-3.256
M3=39.01+1.35M14	0.2221	3.294
M4=76.59+53.46M5	0.1845	2.932
M4=-130.76+418.32M6	0.79	11.957
M4=-14.32+1.92M5	0.5192	6.406
M5=1.99-0.59M12	0.7717	-11.332
M6=0.11+0.82M7	0.7721	11.347
M6=0.34+0.0037M15	0.4404	5.468
M7=0.70-0.07M9	0.0164	-0.797
M7=1.02-0.37M10	0.1233	-2.312
M7=0.23+0.69M11	0.3805	4.831
M8=0.34+0.12M9	0.3384	4.409
M9=0.979-0.006M13	0.1473	-2.562
M9=1.27-0.006M15	0.2939	-3.977
M9=0.165+0.76M10	0.5162	6.368
M10=0.97+0.002M13	0.0379	1.224
M10=0.87+0.002M15	0.1111	2.179
M11=0.28+0.004M15	0.5754	7.716

All equations statistically significant at P<0.01

cial height. When the ratio of UFH/TFH decreases in openbite patients, posterior facial height increases. Openbite subjects have abnormalities in the vertical height of facial structure.

In quadrilateral analysis, the average lower facial height is normally equal to the maxillary or mandibular corpus length. But in cases of AOB, measurements do not follow this equation. In correlation analysis, they do correlate with sagittal angle and posterior facial height; ODI exhibits significant correlation with maxillary length and average lower facial height. Maxillary morphological structure plays an important role in causing openbite. If there is an openbite, there will be differences between maxillary and mandibular corpus and average lower facial height. If the difference is small, the ODI value will be small but the posterior facial height will be great.

In quadrilateral analysis of AOB, our results are consistent with other investigators' results. The morphology of craniofacial pattern presents larger average lower facial height, posterior facial height, sagittal angle, maxillary and mandibular sagittal ratio, shorter maxillary corpus length. If the openbite tendency increases, the difference of maxillary and mandibular corpus lengths with average lower facial height goes up. It seems that the malformation of the craniofacial structure in openbite patients resides in the maxillo-mandibular complex.

Results from the regressive analysis of all measurements, the equations PMax=1.04+0.93 PMan (Table 7), M3 (total maxillary length)=3.76+0.92, and M4 (total mandibular length) (Table 8) show the closest correlation value (R square =0.9515 and 0.9128; P<0.001). Therefore, in conjunction with the ODI, the values of M3 and M4 might be useful as accessary parameters in determing the openbite tendency.

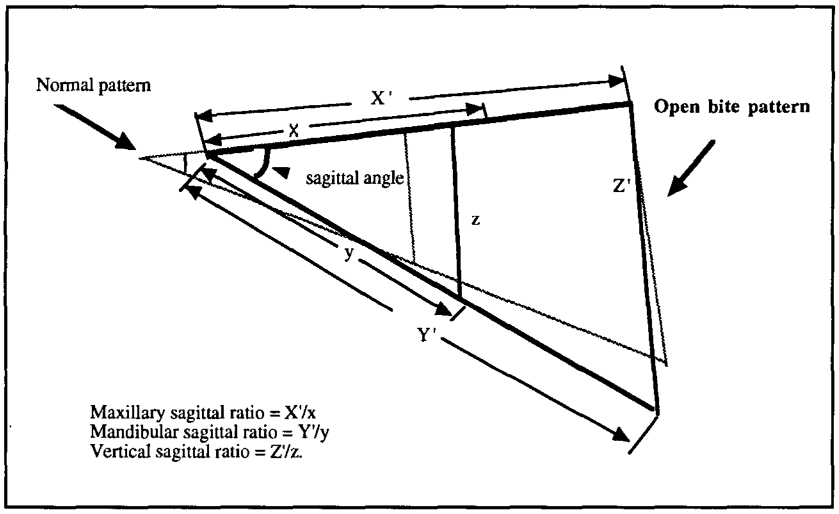

Figure 2

Figure 2
Different measurements of quadrilateral analysis between the normal and openbite groups. Graph is superimposed on palatal plane. Anterior lower facial height, sagittal angle, maxillary sagittal ratio, and mandibular sagittal ratio are larger in the openbite group than in the normal group. Openbite growth pattern is hyperdivergent. The normal group is represented by a broken line, the openbite group by a solid line.

Conclusions

A quadrilateral analysis of the craniofacial structures of a randomly selected group of Taiwanese with AOB was conducted. Our results show the following.

1. The growth pattern of anterior openbite is hyperdivergent.
2. The sagittal angle is larger than normal.
3. The maxillary and mandibular corpus lengths are less than normal.
4. The posterior legs of the maxilla and mandible are shorter than normal.
5. The maxillary and mandibular sagittal ratio are larger than normal.
6. Average lower facial height is greater than normal.
7. Vertical sagittal ratio is larger than normal.

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References

1. Worms FW, Meskin LH, Isaacson RJ. Open-bite. Am J Orthod 1971;59:589-595.
2. Subtely JD, Sakuda M. Openbite: Diagnosis and treatment. Am J Orthod 1964;52:47-49.
3. Peter N, Stephen N, Michael F, Stephen HVW. Treatment of Class II openbite in mixed dentition with a removable functional appliance and headgear. Quintessence Int 1992;23:323-333.
4. Banks PA. An analysis of complete and incomplete overbite in Class II, Division 1 malocclusion. Br J Orthod 1986;13:23-31.
5. Di Paolo RJ. The quadrilateral analysis: Cephalometric analysis of the lower face. J Prac Orthod 1970;3(10):523-530.
6. Nieberg LG. Letter to editor. Am J Orthod 1986;74:83-85.
7. Di Paolo RJ, Markowitz JL, Castaldo DA. Cephalometric diagnosis using the quadrilateral analysis. J Clin Orthod 1970;30-37.
8. Dockell RB. Classification of skeletal facial types. Dent Record 1952;72:25-31.
9. Sassouni V. A classification of skeletal facial types. Am J Orthod 1969;55:109-123.
10. Klein ET. The thumb sucking habit: Meaningful or empty? Am J Orthod 1971;59:283-289.
11. Fletcher BT. Etiology of finger sucking: review of literature. J Dent Child 1975;42:293-298.
12. Speidel TM, Isaacson RJ, Worms FW. Tongue thrust therapy and anterior dental open bite. Am J Orthod 1972;62:287-295.
13. Schudy FF. Vertical growth versus anterior-posterior growth as related to function and treatment Angle Orthod 1964;34:75-93.
14. David ID, Richard JS. Cephalometric and clinical diagnosis of openbite tendency. Am J Orthod 1988;94:484-490.
15. Kim YH. Overbite depth indicator with particular reference to anterior open bite. Am J Orthod 1974;65:586-611.
16. Tseng YK. Quadrilateral analysis on craniofacial morphology in Taiwanese adults. Chin Dent J 1994,13:17-25.
17. Toutountzakis NE, Haralabakis NB. A posterior anterior cephalometric evaluation of adult openbite subjects as related to normals. Eur J Orthod 1991;13(5):410-415.
18. Huang YT, Lin JJ. Long face syndrome of Chinese. Clin Dent Dent J 1984;6:29-34.
19. Rak D. A cephalometric analysis of cases with open bite. Bilten Vdruzenjia Orthodnata Jugoslavij 1990;23(1):19-26.
20. Di Paolo RJ, Anthony CP. LM and John DH. The quadrilateral analysis: A differential diagnosis for surgical orthodontics. Am J Orthod 1984;86(6):470-482.
21. Wardlaw DW, Smith RJ, Hertweck DW, Hidebolt CF. Cephalometric of anterior openbite: A receiver operating characteristic (ROC) analysis. Am J Orthod Dentfac Orthop 1992;101:234-247.