Lower Cranial Height vs Craniofacial Dimensions in Angle Class II Malocclusion

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A statistical evaluation of correlations among stature, cranial heights and jaw relationships, finding much lower correlations in Class II malocclusions.

The cranial floor is the foundation on which the face develops. The human face is located within the recess created by the cranial base flexure. An open cranial base flexure results in a protrusive position of the maxilla relative to the mandible, tending to produce an Angle Class II occlusal relationship.[1-4]

The purpose of the present study was to investigate the horizontal positioning of the maxilla and mandible relative to the cranium in children with Angle Class I and II malocclusions, comparing cranial base angle, upper and lower cranial height, stature and correlations between those variables.

Materials and Methods

The sample consisted of 117 males and 99 females from the serial sample of the Burlington Growth Centre. Of these, 70% had either a normal occlusion or Angle Class I malocclusion, and 30% had a Class II malocclusion.[5] The Class II group consisted of 37 males and 31 females.

Radiographs were oriented on S-N as the horizontal axis, with vertical

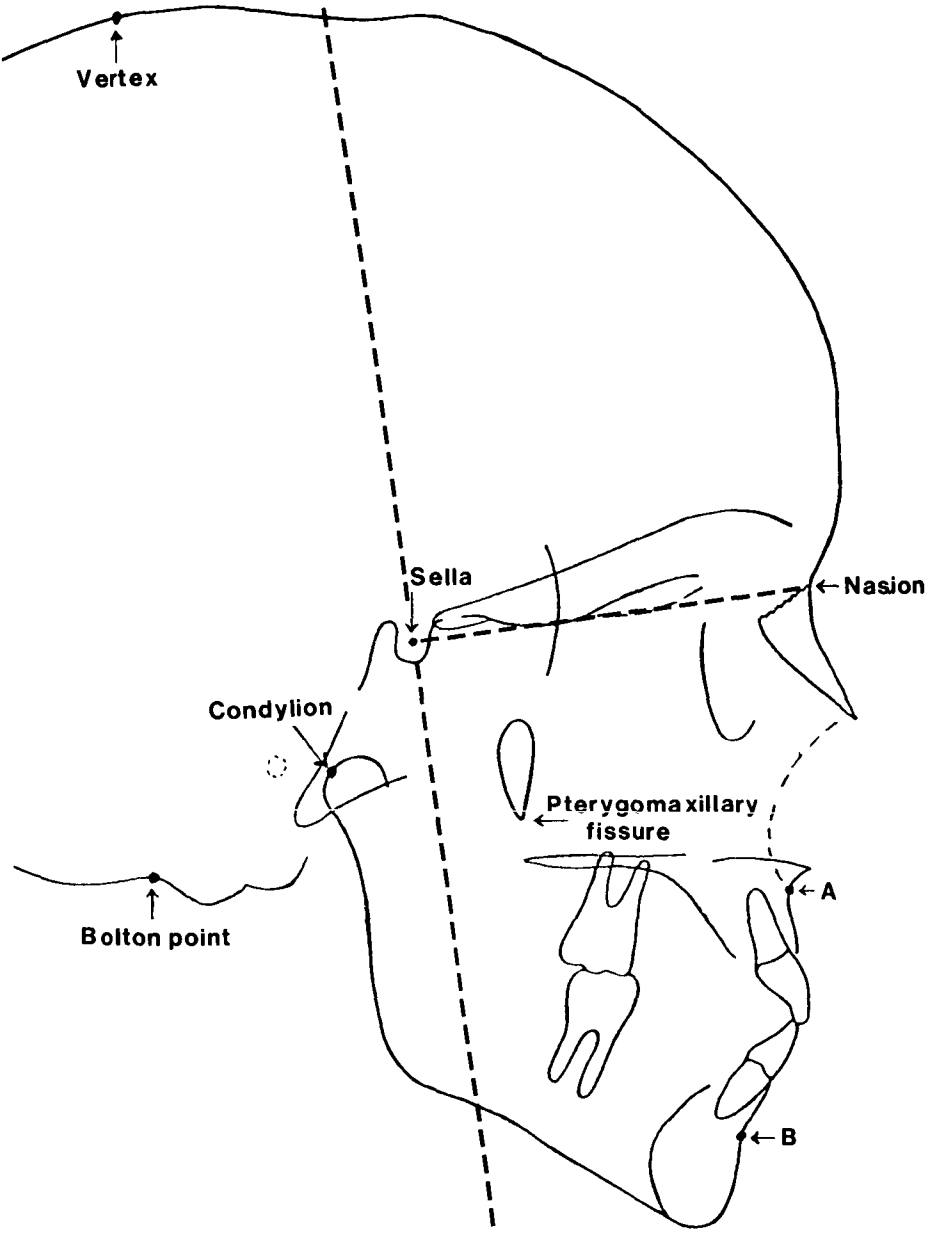

Fig. 1 Cephalometric Landmarks. Note that vertical measurements were made perpendicular to S-N.

TABLE 1

Mean dimensions of cranium and stature at ages 8, 12, and 16 years.

Dimension (mm)		*Cranial Height Vertex to Bolton*			*Upper Cranial Height Vertex to Sella*			*Lower Cranial Height Sella To Bolton*			*Cranial Base Angle Nasion-Sella-Bolton*			*Stature (cm.)*		
Age (yrs)		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Sex	*Class*															
M	I	139.5	141.7	145.2	107.5	107.4	108.7	31.9	34.3	36.5	144.6	144.0	143.4	128.3	149.0	171.9
	II	139.3	141.6	144.4	109.0	108.4	109.5	30.4	33.2	34.8	147.1	145.9	145.6	129.5	151.3	174.3
Significance of difference		—	—	—	NS	NS	NS	NS	NS	NS	.01	.05	.05	—	—	—
F	I	135.7	137.7	139.7	105.7	105.8	107.0	30.0	31.9	32.7	145.8	145.2	145.0	129.1	152.8	162.5
	II	134.9	137.5	138.7	106.3	106.1	107.5	28.5	31.4	31.2	147.5	146.2	146.9	127.7	151.5	163.1
Significance of difference		—	—	—	NS	NS	NS	NS	NS	NS	0.5	NS	.05	—	—	—

measurements made perpendicular to S-N (Fig. 1).

Cephalometric radiographs made at ages 8, 12 and 16 years were evaluated using the folowing measurements.

Stature

Total cranial height, Bolton Point to Vertex (Bo-V)

Lower cranial height, Bolton Point to Sella (Bo-S)

Upper cranial height, Sella to Vertex (S-V)

Cranial base angle, Bo-S/S-N

Distances from Sella to:
- Condylion (Co)
- Pterygomaxillary fissure (PtM)
- Subspinale (point A)
- Supramentale (point B)

All measurements were found to be normally distributed.

For all three ages of each sex, the statistical significance of differences between Angle Class I and Class II subjects in upper and lower cranial heights, cranial base angles and position of the jaws relative to Sella were evaluated for statistical significance with Student's 't' test.

Pearson's correlation coefficients among variables were also computed for each sex at each age.

Results

The cranial base angle was larger in children of the Angle Class II group than in the Class I group ($P < .05$, Table 1). In Class II children, mean upper cranial height was insignificantly greater, and mean lower cranial height was insignificantly smaller than in Class I. Between ages 8 and 16 years, mean lower cranial heights increased and the mean cranial base angle decreased in all groups.

In the Class II children, the anterior and posterior of both the maxilla and mandible were positioned more posteriorly in relation to the cranium than they were in Class I (Table 2). These differences were greater for the mandible than for the maxilla, and several mean values for the mandible were significant at the $P < .05$ level.

The correlation of the cranial base angle with lower cranial height was very strongly negative in both groups (Table 3). Upper cranial height correlated positively with cranial base angle and negatively with lower cranial height (Tables 3 and 4).

Cranial base angle and lower cranial height related significantly to the

TABLE 2

Mean horizontal distances of jaw parameters from Sella at ages 8, 12 and 16 years.

Dimension (mm)		*Sella-CD*			*Sella-PTM*			*Sella-A*			*Sella-B*		
Age (yrs)		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Sex	Class												
M	I	15.2	17.1	18.7	17.8	18.2	19.0	55.7	57.9	61.9	45.1	48.1	52.3
	II	16.8	18.6	20.4	17.6	17.8	18.6	55.1	57.4	60.4	42.5	45.4	48.8
Significance of difference		.05	.05	NS	NS	NS	NS	NS	NS	NS	.05	.05	.05
F	I	14.8	16.7	17.4	17.2	17.7	17.8	53.2	55.2	57.2	42.9	45.4	48.2
	II	15.6	17.6	18.7	17.0	17.5	17.6	53.0	55.1	56.5	40.5	43.7	45.0
Significance of difference		NS	NS	.01	NS	NS	NS	NS	NS	NS	.05	NS	.05

TABLE 3

Correlation of cranial base angle with cranial heights and jaw position.

		Cranial Heights								
		Total			*Upper*			*Lower*		
Age (yrs):		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Class	*Sex*									
I	M	$-.41^{c}$	$-.50^{c}$	$-.41^{c}$	$.52^{c}$	$.41^{c}$	$.46^{c}$	$-.92^{c}$	$-.92^{c}$	$-.91^{c}$
	F	$-.40^{c}$	$-.47^{c}$	$-.51^{c}$	$.31^{b}$	$.32^{b}$	$.38^{b}$	$-.90^{c}$	$-.92^{c}$	$-.92^{c}$
II	M	$-.45^{b}$	$-.54^{c}$	$-.58^{c}$	$.51^{c}$	$.55^{c}$	$.47^{b}$	$-.94^{c}$	$-.95^{c}$	$-.94^{c}$
	F	$-.29$	$-.27$	$-.31^{a}$	$.47^{b}$	$.53^{c}$	$.50^{b}$	$-.94^{c}$	$-.94^{c}$	$-.94^{c}$

		Maxilla and Mandible Position Relative to Cranium											
		Cd-Sella			*PTM-Sella*			*A-Sella*			*B-Sella*		
Age (yrs):		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Class	*Sex*												
I	M	$.41^{c}$	$.51^{c}$	$.53^{c}$	$-.38^{c}$	$-.43^{c}$	$-.35^{c}$	$-.48^{c}$	$-.39^{c}$	$-.35^{c}$	$-.55^{c}$	$-.46^{c}$	$-.45^{c}$
	F	$.32^{b}$	$.31^{b}$	$.37^{c}$	$-.17$	$-.19$	$-.16$	$-.37^{c}$	$-.36^{b}$	$-.34^{b}$	$-.56^{c}$	$-.49^{c}$	$-.41^{c}$
II	M	$.63^{c}$	$.53^{c}$	$.56^{c}$	$-.60^{c}$	$-.55^{c}$	$-.47^{b}$	$-.46^{b}$	$-.38^{b}$	$-.40^{b}$	$-.57^{c}$	$-.56^{c}$	$-.60^{c}$
	F	$.50^{b}$	$.33^{a}$	$.43^{b}$	$-.05$	$-.15$	$-.29$	$-.31^{a}$	$-.29$	$-.45^{b}$	$-.50^{b}$	$-.51^{b}$	$-.60^{c}$

Significance Levels: a = 5%, b = 1%, c = 0.1%

TABLE 4

Correlation of lower cranial height with upper cranial height and jaw position.

Class	Sex	Cranial Ht.			Upper Cranial Ht.			Sella-Co			Sella-PtM			Sella-A			Sella-B		
	Age	8	12	16	8	12	16	8	12	16	8	12	16	8	12	16	8	12	16
I	M	.54^c	.61^c	.50^c	−.47^c	−.37^c	−.45^c	−.28^b	−.37^c	−.38^c	.39^c	.45^c	.35^c	.51^c	.46^c	.39^c	.57^c	.54^c	.48^c
	F	.49^c	.60^c	.58^c	−.30^b	−.24^a	−.38^c	−.20	−.23^a	−.33^b	.12	.16	.19	.43^c	.41^c	.44^c	.62^c	.57^c	.50^c
II	M	.58^c	.62^c	.65^c	−.43^b	−.52^c	−.46^b	−.47^b	−.38^b	−.35^a	.58^c	.48^c	.38^b	.41^b	.34^a	.36^a	.53^c	.54^c	.58^c
	F	.35^a	.36^a	.35^a	−.46^b	−.50^b	−.51^b	−.43^b	−.19	−.31^a	.15	.19	.34^a	.36^a	.32^a	.47^b	.55^c	.53^c	.62^c

Significance Levels: a = 5%, b = 1%, c = 0.1%

dimensions from the mandibular points to Sella in both sexes, but to the distance from Sella to PtM only in males (Tables 3 and 4).

Body stature correlated significantly with total cranial height, but not with upper cranial height (Table 5). Stature correlated significantly with lower cranial height in Class I males and females and in Class II males at age 8 and 12, but not in Class II males at age 16 or in Class II females.

The anterior of the maxilla and mandible relative to the cranium were significantly correlated with body height in the same groups.

Conversely, the distance of the posterior of the mandible from Sella was significantly related to body height only in the Class II females.

The lack of correlation of lower cranial height with stature in Class II children at age 16 is largely explained by the values of those who were moderate or tall in stature, but had small lower cranial height (Table 6). Short lower height was related to large upper cranial height in both Class I and II children (Table 4), but the number of individuals with small lower cranial height and large upper cranial height was greater in the Class II groups.

Discussion

In Nubia over a period of 10,000 years, the human cranium increased in height relative to its length. The face became progressively more inferior and posterior in its position beneath the cranium.[6] This downward and backward rotation of the face under the cranium was proposed by Enlow[1,2] to have occurred with the evolution of the cranial base flexure.

The great enlargement of the human cerebrum relative to the midventral portion of the brain is be-

lieved to be responsible for the marked flexure of the cranial floor which is observed in humans and not in other mammals.[1-4] However, Bolk[7] observed that in the fetal stage, all mammals have a cranial base flexure, but the flexure has been retained through later stages of development only in man.

This suggests the possibility that the presence of the cranial base flexure in adult man may be related to the less specialized development of the face in humans than in other mammals, rather than to enlargement of the human brain.

While the cranial base flexure opens slightly between birth and maturity in chimpanzees and gorillas, it closes an average of 24° in humans.[8] In the

TABLE 5

Correlation of stature with cranial heights and maxilla and mandible position.

		Cranial Heights									*Cranial Base Angle*		
		Total			*Upper*			*Lower*					
Age (yrs):		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Class	*Sex*												
I	M	.29[b]	.42[c]	.44[c]	−.04	.01	.07	.33[c]	.44[c]	.40[c]	−.19	−.29[b]	−.26[a]
	F	.48[c]	.53[c]	.46[c]	.14	.08	−.01	.47[c]	.58[c]	.51[c]	−.32[b]	−.41[c]	−.43[c]
II	M	.43[b]	.43[b]	.35[a]	.11	−.08	.14	.34[a]	.46[b]	.22	−.20	−.32[a]	−.11
	F	.31[a]	.38[a]	.37[a]	.26	.30	.22	.05	.07	.15	.12	.14	.03

		Maxilla and Mandible Position Relative to Sella											
		Cd-Sella			*PTM-Sella*			*A-Sella*			*B-Sella*		
Age (yrs):		*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*	*8*	*12*	*16*
Class	*Sex*												
I	M	.14	.05	−.05	.21[a]	.31[b]	.22[a]	.31[b]	.42[c]	.34[a]	.29[b]	.42[c]	.28[b]
	F	.04	.04	−.16	.10	.27[a]	.19	.33[b]	.47[c]	.29[b]	.36[b]	.54[c]	.33[b]
II	M	.13	.03	.22	.31[a]	.32[a]	.16	−.29[a]	.26	.06	.38[a]	.32[a]	.13
	F	.36[a]	.42[b]	.36[a]	.15	.09	.23	−.00	.12	.18	−.04	.06	.15

Significance Levels: a = 5%, b = 1%, c = 0.1%

TABLE 6

Distribution of lower cranial height by stature at age 16

		Percent Distribution Stature			
		Short	*Medium*	*Tall*	*Total*
Lower Cranial Height in Class I cases.	Small	8.0	8.1	0.7	16.8
	Medium	10.9	39.4	8.8	59.1
	Large	2.2	10.2	11.7	24.1
	Total	21.1	57.7	21.2	100.0%
Lower Cranial Height in Class II cases.	Small	5.8	16.2	8.9	30.9
	Medium	14.7	22.0	13.3	50.0
	Large	1.5	7.4	10.2	19.1
	Total	22.0	45.6	32.4	100.0%

present study, the cranial base angle was found to decrease between the ages of 8 and 16 years in all groups.

An open cranial base flexure is reported to result in a protrusive position of the maxilla, a retrusive mandible and a tendency to Class II malocclusion in humans.[1-4] Many other factors, of course, can be involved in causing a Class II molar relationship.[5] In the present study, the cranial base angle was slightly more open in the Class II children than in the Class I.

The cranial base angle was very strongly related to the relationship between upper and lower cranial height.

Upper cranial height is mainly determined by cerebral size, unrelated to body stature. Lower cranial height, in contrast, tends to be proportional to body stature.

The anterior positions of the jaws relative to the base of the cranium was also different in the Class II children, while the posterior position of the mandible was more proportional to stature in Class II girls.

Tall Class II girls tended to have a more posterior position of the mandibular condyle. while tall Class I girls tended to a more forward position of the anterior of the mandible. In all the relationships of stature to craniofacial dimensions, the girls showed greater differences between Class I and Class II groups than boys.

During human evolution, the height of the cranium has increased relative to its length.[6,7] As the height of the lower cranium increases, the flexure of the cranial base becomes more closed and the condyle of the mandible more anterior, but if the height of the lower cranium does not increase relative to body stature, the cranial base angle will be more open, the condyle is more posterior relative to the maxilla, and the probability of a Class II molar relationship increases.

Summary

From the serial sample of the Burlington Growth Centre, 68 children with Angle Class II malocclusion were contrasted with 148 children with Class I occlusion. Body height, cranial height, cranial base flexure and jaw position relative to the cranium were compared at ages 8, 12 and 16 years.

In the Class II groups, the cranial base angle was significantly ($P < .05$) larger, upper cranial height was slightly larger, lower cranial height was slightly smaller, the maxilla was slightly more posterior to Sella, and the mandible was significantly more posterior.

Between ages 8 and 16 years, lower cranial height increased and cranial base angle decreased, with a strong negative correlation. Lower cranial height and the anterior position of the maxilla and mandible from Sella correlated significantly ($P < .01$) with body height in Class I children, but in Class II only in boys 8 and 12 years of age. This lower correlation in Class II children was accounted for by those with a moderate to tall stature but disproportionately small lower cranial height.

In Class II children the jaws, especially the mandible, had a more posterior position under the cranium, and there was a more open flexure of the cranial base and shorter lower cranial height.

Correlation of stature with lower cranial height and with the anterior position of the jaws relative to the cranium was much lower in Class II children, especially in girls.

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