The Prediction of Facial Growth

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Orthodontic treatment is usually carried out on the child patient who is growing and developing in accordance with the individual genetic pattern. The pioneer work of Holly Broadbent[2] suggested that, in the average case, the face grows steadily downwards and forwards along a straight line, but more recently Björk[1] and others have shown that the individual variations round this mean pattern may be considerable. In some cases the mandible becomes more protrusive, in others the mandible becomes more retruded relative to the maxilla and cranial base.

In recent years progress has been made in the prediction of facial growth notably by Ricketts et al.[12] and Popovich and Thompson.[9] Most present-day methods depend upon the existing facial pattern in conjunction with average growth values for an appropriate group. Although such methods may be useful, they lack precision and are liable to give fallacious estimates for patients whose facial growth deviates appreciably from the average pattern. The present investigation represents the first steps in an attempt to predict facial growth on the basis of parts of the craniofacial skeleton which mature at an early age.

Lindegard[7] and Solow[13] have shown that measurements of the craniofacial skeleton may be associated with each other and Osborne and DeGeorge,[8] Howells[5] and Hunter[6] have found that height dimensions show marked evidence of genetic control. The well-known work of De Coster[3] and Ford[4] led to the conclusion that the endocranial outline tends to reach a stable size at an early age.

If an association could be shown between measurements of the endocranium which reach their final form in the young patient and measurements of the face which are not determined until the end of the skeletal growth period, the possibility of predicting individual facial growth is obvious.

The hypothesis tested in the present investigation is that a good correlation exists between the vertical height of the lower face (ANS-Menton) and the size and shape of the endocranial outline as seen in profile projection.

MATERIAL AND METHODS

Ninety degree left lateral cephalometric radiographs of fifty open-bite cases with a large lower face height and fifty deep overbite cases with a low lower face height were collected. All subjects were at the late teenage or early adult stage when facial growth is virtually complete. In the open-bite group there were 13 males and 37 females and in the deep overbite group 19 males and 31 females. Tracings of each radiograph were orientated with sella-nasion horizontal and the following points defined (Fig. 1): SELLA, NASION, ANS, MENTON, OI (the lowest point on the endocranial outline of the occipital bone), T (the endocranial projection of bone in the region of the transverse sinus), OP (the most posterior point on the endocranial outline of the occipital bone), L (the highest point on the endocranial outline of the lambdoid suture), P (the highest point on the endocranial outline of the parietal bone), C (the endocranial end of the coronal suture), and F (the most an-

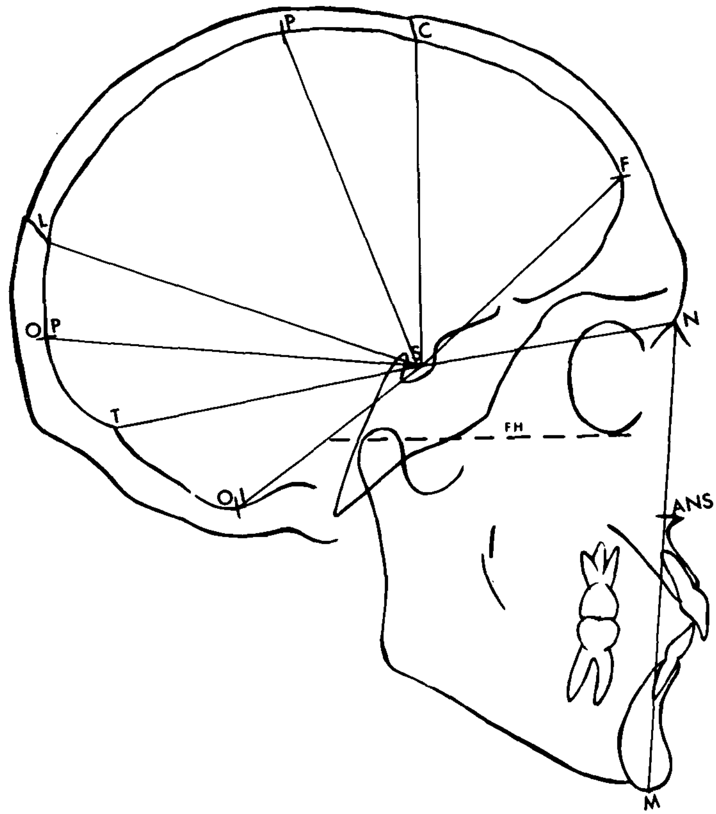

Fig. 1 The cephalometric points and geometric constructions used in the investigation.

terior point on the endocranial outline of the frontal bone).

From sella, radiating lines were drawn to each endocranial point. Using a perspex scale calibrated to 0.5 mm and a large protractor calibrated to 0.5 degrees, the lengths of the lines and the angles between them were accurately determined. In addition, the lower face height from anterior nasal spine to menton was measured along the facial plane joining nasion to menton.

Statistical Analysis

The means of the lower face height, the lengths of the endocranial lines and the angles between them were determined and comparisons made between the open-bite group and the deep overbite group using the "t" test. Then, treating the open bites and deep overbites separately, the endocranial lines and angles were each correlated with the lower face height.

Results

The differences between means and standard errors for the endocranial measurements are shown in Tables I and II. In each case the mean for the deep overbite group was subtracted from the mean for the open-bite

TABLE I

Comparison of Means Open Bite and Deep Overbite Groups, Linear Measurements

Measurement	*Difference Between Means (mm)*	*Standard Error (mm)*	*t*
ANS—M	13.50***	1.22	11.07
S—F	0.02	0.81	0.03
S—C	0.87	0.97	0.90
S—P	—0.01	1.32	0.01
S—L	2.55**	1.17	2.18
S—OP	3.25***	1.16	2.80
S—T	1.97	4.29	0.46
S—OI	0.57	0.98	0.58

** Indicates significance $P < 0.01$
*** Indicates significance $P < 0.001$

TABLE II

Comparison of Means Open Bite and Deep Overbite Groups, Angular Measurements

Measurement	*Difference Between Means (Degrees)*	*Standard Standard Error (Degrees)*	*t*
N—S—F	—2.76***	0.55	5.01
F—S—C	—0.68	0.91	0.75
C—S—P	—2.08*	0.86	2.42
P—S—L	0.55	1.13	0.49
L—S—OP	—0.25	0.54	0.46
OP—S—T	1.01	0.60	1.68
T—S—OI	—2.28*	0.86	2.65

* Indicates significance $P < 0.05$
*** Indicates significance $P < 0.001$

group. Consequently, negative differences indicate that the measurement was greater in deep overbite.

The correlation coefficients between the endocranial measurements and lower face height are shown in Tables III and IV.

TABLE III

Correlation Coefficients Between Lower Face Height and Linear Endocranial Measurements

Endocranial Measurement (mm)	*Open Bite (r)*	*Deep Overbite (r)*
S—F	+0.37**	+0.09
S—C	+0.41**	+0.12
S—P	+0.26	+0.10
S—L	+0.41**	+0.45**
S—OP	+0.38**	+0.18
S—T	+0.29	+0.27
S—OI	+0.36*	+0.23

* Indicates significance $P < 0.05$
** Indicates significance $P < 0.01$

TABLE IV

Correlation Coefficients Between Lower Face Height and Angular Endocranial Measurements

Endocranial Angle (degrees)	*Open Bite (r)*	*Deep Overbite (r)*
N—S—F	+0.15	+0.11
F—S—C	—0.07	+0.12
C—S—P	—0.06	+0.10
P—S—L	—0.13	+0.08
L—S—OP	—0.02	—0.08
OP—S—T	+0.10	+0.06
T—S—OI	+0.02	—0.26

No significant correlations

Discussion

It was no surprise to find that the lower face height was much greater on average in open bite than in deep overbite since this has been demonstrated previously.[10] It was interesting to note, however, that the linear distances S-L and S-OP were significantly greater in the open-bite group, thus indicating that the posterior cranial area is larger on average in open-bite cases. Significant angular differences were more widely distributed including N-S-F anteriorly, C-S-P in the middle area, and T-S-OI posteriorly.

Turning to the correlations between lower face height and endocranial measurements (Tables III and IV); in the open-bite group, significant positive correlation coefficients were shown between lower face height and S-F, S-C, S-L, S-OP and S-OI whereas in deep overbite only one significant correlation coefficient was shown, between lower face height and S-L. This contrast between the two groups is interesting because in a previous publication[11] it was shown that there is a harmony between skeletal elements in open bite but not in deep overbite, and it raises the interesting possibility that the reduced lower face height in deep overbite may be primarily due to dental or muscular rather than skeletal anomalies. There were no significant correlations between angular endocranial measurements and the lower face height.

Summary and Conclusions

In the two contrasting malocclusions, the open bite and the deep overbite, statistically significant differences are shown in the anterior, middle and posterior endocranial regions.

In open bite there is an association between the lower face height and the size of the anterior, middle and posterior cranial regions, but in deep overbite the associations between face height and the endocranial size are less strong.

These and other associations if brought together in a multiple regression analysis may prove useful in prognosticating the final face height in the growing child, particularly in the open-bite case.

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