Original Article

An Investigation Into the Relationship Between the Cranial Base Angle and Malocclusion

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Abstract: A number of authors have suggested that there is a relationship between the degree of cranial base flexion and type of malocclusion, with the angle becoming increasingly obtuse from class III through class I to class II subjects. A retrospective cephalometric study was carried out to examine the contribution of cranial base angle in the four groups of malocclusion as classified by the British Standards Institution. Results showed that the cranial base flexure does not play a pivotal role in determining malocclusion. Jaw size, however, was significantly different between the main classes of malocclusion. The maxilla was found to be longer in class II subjects and the mandible longer in class III subjects. (*Angle Orthod* 2002;72: 456–463.)

Key Words: Cephalometric; Saddle angle; Prognathism; Digitization

INTRODUCTION

The relationship between cranial base configuration and facial prognathism has been of interest to anthropologists, particularly in relation to racial differences. Huxley[1] used the basicranial axis on sagittal sections of dried skulls to elucidate racial variation, whereas Young[2] was one of the first researchers to suggest the possibility of an association between this variable and malocclusion. Bjork,[3] using cephalometric radiographs, demonstrated the existence of a relationship between cranial base morphology and jaw relationship.

The maxilla and mandible articulate with different limbs of the cranial base, and therefore it is possible that variations in growth and orientation of the cranial base region could lead to a differential movement of the mandible in relation to the maxilla.

Anatomy and development of the cranial base

The cranial base forms the floor of the cranial vault and extends from the foramen caecum anteriorly to the basi-occipital bone posteriorly. It is essentially a midline structure comprising parts of the nasal, orbital, ethmoid, sphenoid, and occipital bones. Sella turcica lies near the center of the cranial base and divides it into anterior (sella to nasion) and posterior (sella to basion) limbs.

Although the cranial base largely develops in cartilage (chondrocranium), it depicts both neural (from sella to foramen caecum) and somatic types of growth patterns. Postnatal growth, especially after early childhood, in the anterior segment is mainly due to enlargement of the frontal sinuses and surface remodeling in the nasion region. Posteriorly there is interstitial growth at the spheno-occipital synchondrosis (SOS).

The two limbs of the cranial base form a flexion of 130°–135° at sella. The maxilla appears attached to the anterior segment and the mandible to the posterior segment. It would be reasonable to assume, just from this geometric relationship, that any change in flexion would alter maxillary and mandibular positions relative to the cranial base as well as to each other. This in turn may influence the skeletal pattern and type of malocclusion.

Cranial base angle

The cranial base angle, or saddle angle, is usually measured radiographically as the angle between the basion-sella-nasion points, although the articulare and Bolton points have also been used to describe the posterior limit, making it difficult to compare the results of different studies. The angle at birth is approximately 142°, but then reduces to 130° at 5 years of age. From 5 to 15 years the cranial base angle is relatively stable.[4] An extensive longitudinal study

by Bhatia and Leighton[5] confirmed this stability in both sexes, although there were wide individual variations that ranged from $-7°$ to $+10°$.

Melsen[6] has shown that this relative stability results from a dynamic process whereby flexion at the SOS (due to the neural end of the suture ossifying before the pharyngeal end) is counteracted by resorption of bone at the endocranial and deposition on the pharyngeal surface.

Relationships between the cranial base angle and malocclusion

A number of studies have attempted to identify craniofacial differences between the classes of malocclusion. Hopkin et al,[7] using articulare to represent the posterior limit of the cranial base, described a linear relationship between the cranial base angle and prognathism with the angle systematically reducing from class II, via class I, to class III individuals. The sample consisted of 46 boys and 50 girls (age range 10.24–11 years) in each of the four classes of malocclusion categorized using Angle's classification.[8]

Kerr and Hirst,[9] in a longitudinal cephalometric study using a sample of 85 children from the Belfast Growth Study, found the cranial base angle to be the best discriminator between Angle's class I and class II cases. They also stated that the cranial base angle at age five years was an accurate predictor of the eventual occlusal type of the patient at age 15 in approximately 73% of patients.

Kerr and Adams[10] subdivided a sample of 124 men (mean age range 10.15–10.37 years) on the basis of incisor occlusion and showed a trend of reducing cranial base angles from class II toward class III malocclusion. However, Bacon et al,[11] using a mixed sex sample of eighty-six 10–12 year olds selected on the basis of molar occlusion and ANB angle, concluded that although there was a relationship between cranial base morphology and class II malocclusion, the contribution of the cranial base was limited.

Dibbets[12] found the cranial base angle (Ba–S–N) was reduced and the legs (S–N) and (S–Ba) were shortened systematically from class II, via class I, to class III malocclusions, although the mandible exhibited no systematic difference between these three classes. The material consisted of cephalograms of 170 children divided into the Angle's classes of malocclusion. The distribution of the sample was heavily weighted toward class II (69%) with a mean age of 12.5 years (standard deviation = 3).

More recently, Baccetti et al[13] concluded that the glenoid fossa was more posteriorly positioned in class II than in class III subjects, whereas Singh et al[14] found a closing of the cranial base angle in class III cases.

Other workers have presented contradictory evidence. Renfroe,[15] with a total sample size of 95 subjects, could find no correlation between the cranial base angle and Angle's class I or class II malocclusion. Menezes[16] and Wil-helm et al[17] (in a longitudinal study with a mixed-sex sample of 43 individuals) were also unable to confirm a link between cranial base angle and a class II pattern.

Anderson and Popovich,[18] using material from the Burlington Growth Center, found that large cranial base angles were associated with class II malocclusion, but small angles were related to Angle's class I, rather than class III subjects. Gilmore,[19] using a sample of adults ranging from 16 to 42 years of age, suggested that class II subjects had smaller mandibles than class I subjects. Guyer et al[20] used a cross-sectional sample selected on the basis of a class III molar relationship on cephalometric radiographs to compare with a longitudinal class I sample from the Bolton-Brush study. They also found no association between cranial base angle and type of malocclusion. Similarly, Battagel,[21] using tensor analysis on a sample of 64 children classified using the British Standards Institution incisor method,[22] was unable to show significant differences between the cranial base morphology of class I and class III cases, which led her to conclude that the relationship between cranial base morphology and class III malocclusion was tentative. The class III cases in this study were all classified as suitable for treatment by orthodontics alone.

Clearly the cranial base angle is not the only factor involved in determining malocclusion. Scott[23] suggested that a number of factors determine or influence static jaw position and, consequently, the degree of prognathism in individual cases. These factors included the cranial base angle, the extent to which the mandible and maxilla moved forward in relation to the cranium, and the amount of surface bone deposition along the facial profile from nasion to menton.

In view of the conflicting evidence, a cephalometric study was conducted to explore further the role of the cranial base angle in the various groups of malocclusion.

MATERIALS AND METHODS

Clinical cephalometric records from the orthodontic department of King's College Hospital in London, taken in centric relation, were surveyed and classified by observation into the four categories of malocclusion on the basis of the British Standards Institute incisor classification[22]:

- Class I: The lower incisor edges lie on or below the cingulum plateau on the palatal surface of the upper incisors with a normal overjet.
- Class II, Division 1: The lower incisor edges lie palatal to the cingulum plateau of the upper incisors, and the upper incisors are proclined or of normal inclination with an increased overjet.
- Class II, Division 2: The lower incisor edges lie palatal to the cingulum plateau of the upper incisors with the upper incisors being retroclined. The overjet is usually minimal but may be increased.
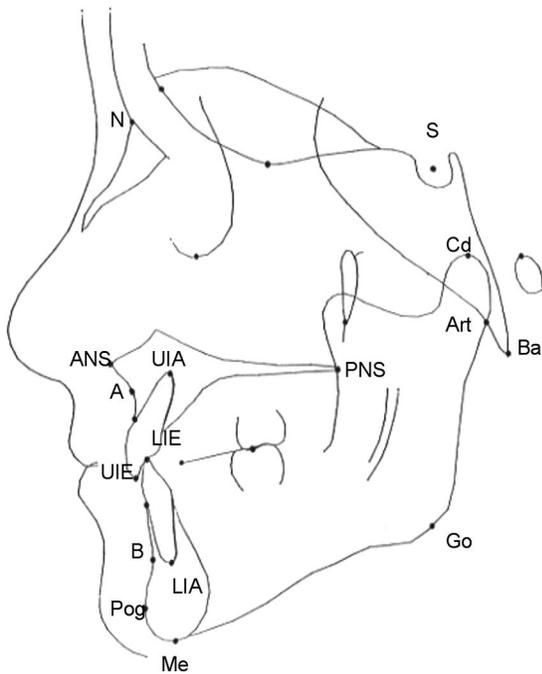
FIGURE 1. Landmarks recorded. Of the 25 points recorded, only those points used to compute variables are labeled. N indicates nasion; S, sella; Ba, basion; Cd, condylion; Art, articulare; Go, gonion; Me, menton; Pog, pogonion; A, A point; B, B point; LIE, lower incisor edge; LIA, lower incisor apex; UIE, upper incisor edge; UIA, upper incisor apex; ANS, anterior nasal spine; PNS, posterior nasal spine.

- Class III: The lower incisor edges lie labial to the cingulum plateau of the upper incisors.

   The British Standards Institute incisor classification represents a measure of the antero-posterior arch discrepancy and is, therefore, analogous to Angle's molar classification. Incisor classification has been used previously to subdivide samples on the basis of malocclusion.[10,21]

   A total of 200 cephalometric radiographs of Caucasian patients (50 for each malocclusion group, with an age range between 8–12 years) were selected for the study. Records were matched for age and sex as far as possible. Each group contained approximately similar numbers of males and females, and the mean ages for each group were 10.4 years for the class I group; 10.10 years for class II, division 1; 11.1 years for class II, division 2; and 10.2 years for the class III group.

   Cephalometric data were collected and stored for analysis by the method of direct on-line digitization as described by Bhatia.[24] Twenty-five landmarks (Figure 1) from each radiograph, as defined by Bhatia and Leighton,[5] were digitized twice and the means of the two sets of coordinates were used for computation of the results. The computer program was designed to highlight any points with a discrepancy of greater than 1 mm between the two recordings in either the horizontal or vertical plane. Such discrepant points were redigitized if it was felt that the cause was

TABLE 1. Results of One-way ANOVA of Relevant Groups

Group	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio (F)	Probability (P)
N–S–Ba	3	234.6	78.2	2.99	.032
N–S–Art	3	353	117.7	4.34	.005
SNA	3	54.9	18.3	1.27	.286
SNB	3	849.8	283.3	22.78	.000
ANB	3	1179.7	393.2	73.95	.000
N–S	3	213.2	71.1	5.44	.001
S–Ba	3	158.7	52.9	5.08	.002
Cd–ANS	3	680.8	226.9	9.35	.000
Cd–Pog	3	938.3	312.8	6.82	.000
ANS–PNS	3	249.7	83.2	7.83	.000
Me–Go	3	287.7	95.9	3.31	.021
ANS–PNS / Me–Go	3	0.10	0.04	11.26	.000

likely to be operator error. From the coordinate means a number of linear and angular variables were calculated:

- Cranial base flexure: N–S–Ba, N–S–Art;
- Jaw position: SNA, SNB;
- Skeletal pattern: ANB, maxillary mandibular planes angle (MMA) measured as the angle between the ANS–PNS and Me–Go planes;
- Dento–alveolar pattern: Imx (upper incisors to maxillary plane angle), Imn (lower incisors to mandibular plane angle), I/I (interincisal angle);
- Cranial base lengths: N–S, S–Ba;
- Jaw lengths: Cd–ANS, Cd–Pog, Art–ANS, Art–Pog, ANS–PNS, Me–Go;
  ANS–PNS: Me–Go.

   The error of the method was estimated by using the Dahlberg formula:

$$\text{Method error} = \sqrt{\frac{\Sigma d^2}{2N}} \qquad (1)$$

Errors were comparable to and showed similar trends to other cephalometric studies (Gravely and Benzies[25]).

   The between group variability was investigated using a one-way analysis of variance (ANOVA). The group variable means for the class II and III groups were compared with the class I group by means of an independent *t*-test. Because of the large number of comparisons and to reduce the probability that some mean differences might be significant by chance alone, the minimum probability level for accepting significance between the group means was set at 1%. Intervariable correlations were also compiled. For clarity, only relevant correlations are presented.

RESULTS

   The results are presented in Tables 1–8. First, it was necessary to demonstrate that the data for each variable showed

TABLE 2. Comparison of Skeletal and Dental Variables Between the Class I and Class II Sample Groups

Variable	Class I			Class II, Division 1				Class II, Division 2			
	Mean	SD	SE	Mean	SD	SE	t	Mean	SD	SE	t
N–S–Ba	131.4	4.84	0.68	134.4	4.95	0.70	−3.10**	132.6	4.57	0.64	−1.25
N–S–Art	124.7	4.99	0.70	128.1	5.47	0.77	−3.40**	124.9	4.40	0.62	−0.20
SNA	79.83	3.31	0.46	79.52	3.93	0.55	0.43	80.42	4.19	0.59	−0.79
SNB	76.93	3.11	0.44	74.37	3.56	0.50	3.84***	76.33	3.55	0.50	0.90
ANB	2.90	2.08	0.29	5.15	1.59	0.22	−6.18***	4.08	2.03	0.28	−2.93**
MMA	29.13	5.70	0.80	30.19	5.71	0.80	−0.94	24.98	4.39	0.62	4.10***
Imx	106.9	7.86	1.11	111.7	7.43	1.05	−3.14**	92.76	5.26	0.74	10.06***
Imn	90.72	6.46	0.91	92.96	6.40	0.90	−1.75	84.27	6.76	0.95	4.90***
I/I	133.2	11.51	1.62	126.1	9.86	1.39	3.33**	157.9	8.09	1.14	−12.49***
N–S	70.00	3.73	0.52	72.00	3.01	0.42	−2.99**	72.27	4.35	0.61	−2.83***
S–Ba	42.80	2.59	0.36	44.88	3.25	0.46	−3.56***	44.36	3.65	0.51	−2.50*
Cd–ANS	88.41	4.82	0.68	90.95	4.13	0.58	−2.84**	92.20	5.80	0.82	−4.06***
Cd–Pog	110.1	6.07	0.85	110.5	5.65	0.79	−0.34	113.0	7.79	1.10	−2.06*
Art–ANS	88.13	4.56	0.64	91.42	4.17	0.59	−3.78***	91.83	5.67	0.80	−3.61***
Art–Pog	102.1	5.56	0.78	103.1	5.51	0.78	−0.91	104.6	7.35	1.03	−1.90
ANS–PNS	51.63	3.30	0.46	53.65	3.07	0.43	−3.21**	54.07	3.58	0.50	−3.60***
Me–Go	68.26	5.67	0.80	68.25	4.31	0.60	0.01	69.51	5.47	0.77	−1.13
ANS–PNS / Me–Go	0.76	0.06	0.008	0.79	0.04	0.006	−3.00*	0.78	0.05	0.007	−1.87

* $P < .05$.
** $P < .01$.
*** $P < .001$.

TABLE 3. Comparison of Skeletal and Dental Variables Between the Class I and Class III Sample Groups

Variable	Class I			Class III			
	Mean	SD	SE	Mean	SD	SE	t
N–S–Ba	131.4	4.84	0.68	133.0	5.80	0.82	−1.50
N–S–Art	124.7	4.99	0.70	123.7	5.64	0.79	0.95
SNA	79.83	3.31	0.46	78.98	3.52	0.49	1.26
SNB	76.93	3.11	0.44	80.11	3.69	0.52	−4.67**
ANB	2.90	2.08	0.29	−1.14	3.06	0.43	7.79**
MMA	29.13	5.70	0.80	28.77	4.77	0.67	0.34
Imx	106.9	7.86	1.11	112.4	7.91	1.11	−3.50***
Imn	90.72	6.46	0.91	87.03	6.31	0.89	2.90***
I/I	133.2	11.51	1.62	131.8	11.25	1.59	0.62
N–S	70.00	3.73	0.52	70.16	3.03	0.42	−0.24
S–Ba	42.80	2.59	0.36	42.26	3.17	0.44	0.95
Cd–ANS	88.41	4.82	0.68	87.57	4.58	0.64	0.78
Cd–Pog	110.1	6.07	0.85	115.5	7.08	1.00	−4.11**
Art–ANS	88.13	4.56	0.64	86.97	4.50	0.63	1.30
Art–Pog	102.1	5.56	0.78	107.8	6.76	0.95	−4.64**
ANS–PNS	51.63	3.30	0.46	51.66	2.90	0.41	−0.08
Me–Go	68.26	5.67	0.80	71.42	5.73	0.81	−2.78***
ANS–PNS / Me–Go	0.76	0.06	0.008	0.72	0.05	0.007	3.74**

** $P < .01$.
*** $P < .001$.

significant variance in the four malocclusion groups so as not to invalidate comparisons between individual malocclusion groups. This was done using a one-way ANOVA of relevant groups (Table 1). Tables 2 and 3 show values for all variables and also between-group comparisons of variables according to independent *t*-tests. Table 4 shows the salient and significant intervariable correlations compiled using pooled data from all four malocclusions. Tables 5–8 show intervariable correlations for each malocclusion group.

Cranial base parameters

The cranial base angle, calculated according to both N–S–Ba and N–S–Art, was found to be significantly larger in

TABLE 4. Correlation Coefficients With Pooled Group Data

	N–S–Art	N–S–Ba	S–Ba	N–S	SNA	SNB
SNA	−0.53**	−0.54**	0.14*	−0.17*	—	—
SNB	−0.55**	−0.48**	−0.08	−0.18*	—	—
ANB	0.06	0.03	0.16*	0.33	—	—
ANS–PNS	0.07	0.04	0.32**	0.51**	0.26**	0.02
Me–Go	0.02	0.003	0.28**	0.42**	0.19	0.41**

  * Correlation is significant at the .05 level.
  ** Correlation is significant at the .01 level.

TABLE 5. Class I Correlation Coefficients

	N–S–Art	N–S–Ba	S–Ba	N–S	SNA	SNB
SNA	−0.50**	0.55**	−0.03	−0.25	—	—
SNB	−0.49**	−0.54**	0.14	−0.19	—	—
ANB	−0.07	−0.07	−0.26	−0.11	—	—
ANS–PNS	0.01	−0.128	0.37**	0.40**	0.10	0.02
Me–Go	−0.01	−0.060	0.24	0.43**	0.16	0.31*

  * Correlation is significant at the .05 level.
  ** Correlation is significant at the .01 level.

TABLE 6. Class II Division 1 Correlation Coefficients

	N–S–Art	N–S–Ba	S–Ba	N–S	SNA	SNB
SNA	−0.51**	−0.58**	0.26	−0.31*	—	—
SNB	−0.50**	−0.55**	0.19	−0.19	—	—
ANB	−0.15	−0.22	0.22	−0.34*	—	—
ANS–PNS	−0.05	−0.09	−0.06	0.33*	0.27	0.29*
Me–Go	0.14	0.09	0.29*	0.38**	0.14	0.24

  * Correlation is significant at the .05 level.
  ** Correlation is significant at the .01 level.

TABLE 7. Class III Correlation Coefficients

	N–S–Art	N–S–Ba	S–Ba	N–S	SNA	SNB
SNA	−0.55**	−0.47**	0.16	0.01	—	—
SNB	−0.46**	−0.42**	0.14	0.17	—	—
ANB	−0.09	−0.03	0.01	−0.18	—	—
ANS–PNS	0.23	0.35*	0.19	0.53**	0.28*	0.09
Me–Go	0.01	0.07	0.26	0.49**	0.34*	0.55**

  * Correlation is significant at the .05 level.
  ** Correlation is significant at the .01 level.

TABLE 8. Class II Division 2 Correlation Coefficients

	N–S–Art	N–S–Ba	S–Ba	N–S	SNA	SNB
SNA	−0.71**	−0.65**	0.07	−0.22	—	—
SNB	−0.69**	−0.65**	0.13	−0.16	—	—
ANB	−0.26	−0.22	−0.09	−0.17	—	—
ANS–PNS	−0.08	−0.11	0.49**	0.57**	0.34*	0.27
Me–Go	−0.05	−0.10	−0.52**	0.53**	0.22	0.39*

  * Correlation is significant at the .05 level.
  ** Correlation is significant at the .01 level.

class II division 1 subjects than in the class I group. This difference was not seen between class I subjects and the other two malocclusion groups (Tables 2 and 3).

The cranial base lengths, N–S and S–Ba, were significantly larger in both divisions of class II malocclusion than in class I subjects, but the measurements were very similar in class I and class III.

Maxillary skeletal parameters

Angle SNA (Fig. 1) showed no significant variation between class I subjects and the other groups. However, Cd–ANS, Art–ANS, and ANS–PNS showed statistically significant variation. All distances were significantly increased above class I values in class II division 1 and class II division 2 groups. No significant differences were found for these lengths between class I and class III subjects.

Mandibular skeletal parameters

Mandibular length measurements Cd–Pog, Art–Pog, and Me–Go were similar in class I and class II subjects, although they were significantly larger in the class III group. This finding that mandibular prognathism was greatest in class III subjects was also reflected in angle SNB, which was largest in the class III group. The maxillary/mandibular lengths ratio, as defined by ANS–PNS/Me–Go, showed corresponding variation between the groups in that angle ANB was largest in class II subjects and smallest in the class III group.

Correlation results for pooled data

Both cranial base angles were correlated inversely with angles SNA and SNB ($P < .01$; Table 4). There was little relationship between cranial base angles and jaw lengths, with the correlations being nearly zero. However, jaw lengths did influence the measurement of facial prognathism according to SNA and SNB. The correlation between maxillary length and angle SNA was small but statistically significant at $+0.26$; correlations between mandibular lengths and SNB angle were somewhat stronger, around $+0.4$. There was no apparent link between cranial base angle and skeletal base pattern as indicated by variable ANB.

The posterior cranial base length (S–Ba) showed no relationship with mandibular prognathism as measured by angle SNB, but did show a link with angle SNA ($P < .05$). There was also an association between the anterior cranial base length N–S with maxillary and mandibular prognathism as measured by angles SNA and SNB, respectively ($P < .05$).

The correlation matrices for each individual class of malocclusion (Tables 5–8) showed similar trends, in particular with respect to cranial base angle.

DISCUSSION

The sample consisted of 200 cephalometric radiographs selected retrospectively on the basis of the observed incisor

occlusion. The class I sample showed good agreement with published cephalometric norms for both dental and skeletal base relationships.[26] Interestingly these figures also agree very closely with those recently published by Hamdan and Rock[27] who calculated the mean of means for major cephalometric variables using data from 14 prominent studies. The sample, therefore, represents a valid reference group for the purposes of this study.

Data for the other malocclusion groups showed the expected variations in terms of dentoalveolar and skeletal base patterns with the skeletal pattern for each group matching the incisor relationship. The dental angular variations were as would be expected in order to compensate for the underlying skeletal discrepancies in the respective classes of malocclusion. For example, when compared with class I values the lower incisors were retroclined in class III subjects.

Although the N–S length is usually used as a measure of the anterior cranial base, there is some disagreement as to whether the posterior base should be measured from basion or articulare. Bjork[3] advocated the use of articulare, rather than basion, because it is easier to identify. Subsequently other studies have used articulare to define the posterior limit of the cranial base.[7]

Varjanne and Koski[28] have discouraged the use of articulare because of its remoteness from the cranial base and suggested basion as the more appropriate choice because of its anatomic significance despite potential difficulties in identification. Kerr and Adams[10] used basion to measure the cranial base angle. Bhatia and Leighton[5] have published figures for N–S–Ba and N–S–Art angles as well as the S–Ba and S–Art distances. Interestingly, they found the growth patterns, as described by use of basion or articulare, to be very similar.

The present results, using both measures of the posterior cranial base, do not support the concept that the cranial base angle, by providing a variation in the antero-posterior position of the mandibular articulation, is a major determinant in establishing the main classes of malocclusion.[7] Indeed, only the class II division 1 group showed a significant difference in parameters N–S–Ba and N–S–Art in comparison to class I. Therefore, it is not possible to corroborate the assertion of Dibbets[12] that the three Angle classes II, I, and III represent arbitrary markers on a morphological continuum.

Enlow[29] has shown growth of the maxilla to be under the influence of the cranial base, which in turn is influenced by growth of the brain. The mandible, by virtue of its remoteness from the region, acts in a more independent way although its articulation at the glenoid fossa does provide potential for influence from the cranial base.

It should be noted that the temporo-mandibular joint is positioned at the lateral edges of the cranial base and is, in fact, considerably separated spatially from the midsagittal plane on which cephalometric analyses are based. It is like-

ly, therefore, that changes in the cranial base angle may not be directly translated to the mandibular articulation. The trends found in the present study with regard to the maxillary and mandibular skeletal parameters agree with those reported by other researchers.[20,21]

The finding from the pooled sample that cranial base angle was correlated to the angles SNA and SNB is in agreement with those of Bjork[3] and Kasai et al,[30] who demonstrated a relationship between the cranial base angle and facial prognathism.

The correlation analysis also suggests a relationship between mandibular position and the magnitude of cranial base flexure. The smaller the cranial base angle, the more forward the mandibular position, as indicated by angle SNB. However, it is impossible to establish cause or effect from these results since other factors may also be involved. The maxilla is equally affected by the angle, which suggests a more fundamental role for the cranial base in determining facial prognathism than that indicated by mere geometry. When interpreting the present results, it is also important to realize that angular correlations, which share a line or point, are not devoid of topographical influence.

Little correlation was evident between angle ANB and cranial base parameters when looking at pooled or individual group data (Tables 4–8). This suggests that there is no direct relationship between the cranial base and class of malocclusion. The positive and significant correlations between S–Ba and N–S distances with maxillary and mandibular lengths are likely to be topographical and of little biological significance. The results, however, do suggest a link between jaw length and facial prognathism. This relationship was most pronounced in class III subjects where a longer mandible was associated with increased mandibular prognathism.

Wide fluctuations in the magnitude of the cranial base angle have been remarked upon by a number of authors[31] and make it difficult to interpret some of the present results. Differences between these results and those of other workers may be related, in part, to differences in case selection procedures. The cases for this study were selected on the basis of the unmodified British Standards Institute incisor classification.[22] Kerr and Adams,[10] for example, selected cases with more definite malocclusion, ie, class II division 1 cases with overjet $\geq$10 mm and class III subjects with maxillary incisors in lingual occlusion. It may well be that cranial base morphology has a more prominent role in establishing malocclusions at the extremes of the scale.

CONCLUSIONS

From the present study the following conclusions may be drawn:

1. The cranial base angle alone does not appear to play a pivotal part in the establishment of malocclusion.

2. Jaw lengths are significantly different between the malocclusion groups. The maxillary length is increased in class II malocclusions and the mandibular length is greater in class III.

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