# The Cranial Base as an Aetiological Factor in Malocclusion*

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## Introduction and Review

The cranial base area of the craniofacial complex has long been of interest to orthodontists. However, as Krogman and Sassouni[1] point out, this interest has arisen largely from attempts to find a relatively stable area of the craniofacial region for use in the many radiographic cephalometric analyses which have been published. Björk[2,3,4] in a series of papers drew attention to the parts played by the size and shape of the cranial base in determining maxillary and mandibular prognathism and discussed the influence upon the occlusion of alterations in cranial base dimensions. Renfroe[5] recorded a larger mean cranial base angle in his Class II, Division 1 than in his Class I sample but did not refer to this finding in his text. Moss[6] reported a smaller cranial base angle in association with Class III malocclusion and in a further paper (Moss[7]) suggested that a smaller cranial base angle was also associated with cleft palate. Coben[8] examined the effects upon the occlusion of variations in the cranial base and Ricketts[9] and Hopkin[10] made observations on the effect of growth in the posterior area of the cranial base upon mandibular position. The consensus of these papers is that the cranial base area has considerable influence both upon total facial prognathism and in establishing the anteroposterior relationship of upper jaw to lower jaw.

Hopkin,[11] James[12] and Houston[13] in a series of related studies have examined the craniofacial pattern in Class III, Class II, Division 1 and Class II, Division 2 malocclusions, respectively. Their findings are that the linear and angular dimensions of the cranial base tend to be smaller in Class III malocclusions and to be larger in Class II malocclusions when compared with a common control group of children with either normal occlusion or Class I malocclusion. Although individual variations were noted in the dimensions of the maxilla and of the mandible, nevertheless, in all three reports the variations of the cranial base stood out as the most consistent factors associated with anteroposterior malrelationships of the dental arches. The three investigations were planned with a view to their eventual integration and this present report is a collation and further analysis of the data for the cranial base dimensions.

## Material and Methods

The control samples and the samples of the three malocclusions were selected from patients attending the Orthodontic Department of the University of Edinburgh School of Dentistry. The subjects were in the mixed dentition stage of occlusal development which was defined as having the first permanent molars in occlusion but not the second permanent molars. The criteria

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TABLE 1

MEAN DIFFERENCES AND STANDARD ERRORS OF MEAN DIFFERENCES OBTAINED BY THREE INVESTIGATORS FOR INDEPENDENT DETERMINATIONS OF THE CRANIAL BASE DIMENSIONS OF THE SAME 30 RADIOGRAPHS.

| | A - B | | B - C | | C - A | |
|---|---|---|---|---|---|---|
| N-S | —0.36 | (0.19) | —0.03 | (0.16) | +0.39 | (0.20) |
| S-Ar | —0.09 | (0.16) | +0.51 | (0.20) | —0.42 | (0.19) |
| Ar-N | —0.16 | (0.18) | —0.17 | (0.20) | +0.33 | (0.18) |
| N-S-Ar | +0.02 | (0.30) | —0.52 | (0.35) | +0.50 | (0.32) |

*NOTE*:— A = G.B.H. B = W.H. C = G.A.J.

TABLE 2

AGE DISTRIBUTION OF SUBJECTS IN MAIN SAMPLES

MALES (N = 46)

| Age | Class I (Control) | II, Div. 1 | II, Div. 2 | III |
|---|---|---|---|---|
| 6 | 1 | — | — | — |
| 7 | 9 | 2 | 1 | 2 |
| 8 | 4 | 7 | 1 | 7 |
| 9 | 6 | 10 | 5 | 8 |
| 10 | 3 | 10 | 11 | 20 |
| 11 | 16 | 10 | 10 | 5 |
| 12 | 3 | 3 | 10 | 2 |
| 13 | 2 | 2 | 6 | 1 |
| 14 | 2 | 2 | 2 | 1 |
| Mean Age | 10.30 | 10.50 | 11.50 | 10.24 |

FEMALES (N = 50)

| Age | Class I (Control) | II, Div. 1 | II, Div. 2 | III |
|---|---|---|---|---|
| 6 | — | — | — | — |
| 7 | — | 2 | 2 | 2 |
| 8 | 10 | 3 | 3 | 4 |
| 9 | 8 | 13 | 6 | 17 |
| 10 | 14 | 12 | 15 | 13 |
| 11 | 11 | 12 | 9 | 10 |
| 12 | 6 | 8 | 11 | 2 |
| 13 | 1 | — | 4 | 2 |
| 14 | — | — | — | — |
| Mean Age | 10.46 | 10.56 | 11.00 | 10.28 |

used for occlusal classification and the radiographic and tracing techniques employed in the three studies have been described in detail elsewhere.[10,12,18] The problem of variation between the three investigators was reduced to a minimum by careful standardization and comparison of techniques. A statistical analysis has been made of the individual variations in tracing the same series of radiographs; the results are shown in Table 1.

It can be seen that the maximum mean differences do not exceed 0.5 mm for the linear measurements or 0.5° for the angular measurements and it can

safely be said that the mean differences are not large enough to affect the validity of the conclusions drawn from a comparison of the findings of the three investigations.

The original samples consisted of the following: control group, normal or Class I, 54 girls and 47 boys; Class II, Division 1, 50 girls and 50 boys; Class II, Division 2, 50 girls and 50 boys; and Class III, 67 girls and 61 boys.

The age range of the samples was made as comparable as possible by eliminating some of the cases in the various samples. This resulted in equal samples of forty-six boys and fifty girls for all of the groups (Table 2). Despite this adjustment, differences in mean ages were still present and a subsample was selected from each main sample with a more limited age range and matched for age (Table 3). The subsamples were rather small in number but they were of value in determining whether differences between the main samples were due merely to age. The cranial base dimensions measured were: anterior cranial base length, nasion-sella (N - S); posterior length, sella-articulare (S - Ar); overall length, articulare-nasion (Ar - N); and the cranial base angle, nasion-sella-articulare (∠NSAr).

Differences between sample means were tested using an analysis of variance.[14] Only if $F$ was significant were differences between pairs of samples tested using Student's $t$ test. The data were processed on an I.B.M. 7090 computer.

TABLE 3

AGE DISTRIBUTION IN MATCHED SUBSAMPLES FROM EACH MAIN SAMPLE

| | Males (N = 20) | Females (N = 29) |
|---|---|---|
| Age | | |
| 9 | 5 | 6 |
| 10 | 3 | 12 |
| 11 | 10 | 9 |
| 12 | 2 | 2 |
| Mean Age | 10.95 | 10.74 |

## Results

When the samples are arranged in the order Class III, Class I, Class II, Division 2 and Class II, Division 1, a definite trend emerges, the values of the Class III being least and of the Class II, greatest. The presence of significant differences among sample means is demonstrated by $F$ which is significant at the one per cent level for all the cranial base values investigated (Table 4).

Overall cranial base length (N - Ar) differs significantly for all comparisons except those between the Class II, Division 1 and Class II, Division 2 groups. These are not age differences as a similar pattern is demonstrated by the subsample matched for age as described above (Table 4).

Anterior cranial base length (N - S), posterior cranial base length (S - Ar) and cranial base angle (∠N - S - Ar) are all to some extent responsible for the differences in overall cranial base length (Table 4).

The values of the various measurements do not always differ significantly when adjacent samples are compared, e.g., Class III with Class I (tA) or Class I with Class II, Division 2 (tB) or Class II, Division 2 with Class II, Division 1 (tC). When, however, Class III is compared with Class II, Division 2 (tD) or Class II, Division 1 (tF) or when Class I is compared with Class II, Division 1 (tE), all the differences are significant with the exception of posterior cranial base length in Class I and Class II, Division 1 (tE).

In discussions on the aetiology of Angle's Class II and Class III malocclusions attention has not unnaturally tended to concentrate on the form and

TABLE 4

LINEAR VALUES (M.M.) AND ANGULAR VALUES (DEGREES)
CRANIAL BASE VALUES FOR MAIN SAMPLES — 46 MALES, 50 FEMALES IN EACH GROUP

| | | Class III Mean | (SD±) | Class I Mean | (SD±) | Class II Div. 2 Mean | (SD±) | Class II Div. 1 Mean | (SD±) | F | tA | tB | tC | tD | tE | tE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N-S | (M) | 70.47 | (2.89) | 71.48 | (3.05) | 73.83 | (3.44) | 73.34 | (2.45) | ** | — | ** | — | ** | ** | ** |
| | (F) | 67.77 | (2.82) | 69.19 | (2.87) | 71.31 | (3.29) | 71.48 | (3.01) | ** | * | ** | — | ** | ** | ** |
| S-Ar | (M) | 33.17 | (3.36) | 34.21 | (4.04) | 35.99 | (3.51) | 35.25 | (2.87) | ** | — | * | — | ** | — | ** |
| | (F) | 31.15 | (2.07) | 33.20 | (3.19) | 34.54 | (3.25) | 33.85 | (3.12) | ** | ** | * | — | ** | — | ** |
| N-Ar | (M) | 92.44 | (4.59) | 95.32 | (5.00) | 98.94 | (4.88) | 98.59 | (4.11) | ** | * | ** | — | ** | ** | ** |
| | (F) | 88.24 | (3.86) | 91.81 | (4.31) | 95.61 | (4.42) | 96.46 | (4.59) | ** | ** | ** | — | ** | ** | ** |
| N-S-Ar | (M) | 122.43 | (5.06) | 124.34 | (4.76) | 125.06 | (4.99) | 126.77 | (4.89) | ** | — | — | — | * | * | ** |
| | (F) | 122.20 | (4.73) | 124.18 | (5.18) | 125.45 | (4.80) | 128.89 | (4.49) | ** | * | — | ** | ** | ** | ** |
| OVERALL CRANIAL BASE LENGTH FOR SUBSAMPLES — 20 MALES, 29 FEMALES IN EACH GROUP | | | | | | | | | | | | | | | | |
| N-Ar | (M) | 92.73 | (4.23) | 96.42 | (5.20) | 98.40 | (4.98) | 99.10 | (4.59) | ** | * | — | — | ** | — | ** |
| | (F) | 87.55 | (4.52) | 91.26 | (4.15) | 94.97 | (4.46) | 96.64 | (4.81) | ** | ** | ** | — | ** | ** | ** |

** = Significant at 1 per cent level.
* = Significant at 5 per cent level.

Comparisons: — tA = Class III and Class I
tB = Class I and Class II, Div. 2
tC = Class II, Div. 2 and Class II, Div. 1
tD = Class III and Class II, Div. 2
tE = Class I and Class II, Div. 1
tF = Class III and Class II, Div. 1

dimensions of the jaws. Furthermore, with few exceptions, most investigations have been concerned with only one or at most two of Angle's classes of malocclusion and a control sample. In the present investigation comparisons have been made between all classes of malocclusion.

When the results are tabulated (Table 4) the common feature of all dimensions noted is the progression from the Class III group through the control sample (normal occlusion and Class I) to the Class II groups. The mean linear dimensions of the cranial base and the cranial base angle itself all show the smallest values in the Class III group and the largest values in the Class II groups.

It is clear, therefore, that the cranial base has an important role in determining anteroposterior jaw relationships and occlusion of the teeth.

It is considered that, in the assessment of orthodontic problems involving anteroposterior malrelationships of the jaws and arches, recognition must be given to the determining role of the cranial base. The inclusion of the cranial base in the diagnostic assessment brings in as a major factor an area of the craniofacial complex not normally taken into account in diagnosis. Nor is it regarded as susceptible to conventional orthodontic therapy although the recent work of Wieslander[15] suggests the possibility of inducing changes in this area by sustained extraoral traction on the maxilla.

## Summary

A radiographic cephalometric analysis of the cranial base dimensions of Class II, Division 1, Class II, Division 2, Class III and Class I (control sample) has been made.

The results show that there is a progressive and significant increase for all the cranial base dimensions from the Class III group through the Class I (control) group to the Class II groups.

It is concluded that the dimensions of the cranial base are a major factor in determining anteroposterior relationships of the jaws and the dental arches which must be taken into account in diagnosis and treatment.

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