Some Aspects of Facial Depth in Class II, Division 1 Malocclusion*

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Angle[1] was of the opinion that "the facial deformity produced by malocclusion in each Class is so distinctive and constant that after some practice the orthodontist may even classify with considerable accuracy the malocclusion of the people he meets without an actual examination of their teeth." He maintained that the facial form associated with Class II, division 1 malocclusion was influenced primarily by the size and position of the mandible. Despite valid criticism by Case[7] and Simon[21] this hypothesis was accepted almost universally, and it was restated by Brodie[5] just before the introduction of cephalometric radiography.

Fisk et al.[14] summarized the conclusions of recent studies dealing with Class II, division 1 malocclusion. Unfortunately, lack of critical analysis of the original findings of these studies detracted from the potential value of their summary.

Preference has been given to the measurement of angular relationships in cephalometric radiography. Linear determinations permit further appraisal of an area or part in terms of its influence on the configuration of the whole face. An advantageous combination of angular and linear measurements is exemplified by the study of Björk.[4]

Elsasser and Wylie[13] and Wylie[25] determined the "effective" contribution of various facial dimensions to the form of the bony profile by measuring projected, instead of actual, distances between two landmarks. In the latter study, for instance, the effective length of the mandible was obtained by measuring the distance between the head of the condyle and gnathion as a projection on the Frankfort horizontal. Wylie[25] and Wylie and Johnson[36] made separate analyses of facial height and depth. However, these variables may be studied together when two coordinates perpendicular to each other are used, one related to a suitable line of reference such as sella-nasion (Williams[23]) or the Frankfort horizontal (Coben[8] and Craig[9]).

In the present study the method of projecting distances between different landmarks on two coordinates was used in the analysis of the cephalometric radiographs of two groups of children, one with "normal" occlusion and the other with Class II, division 1 malocclusion. The purpose of this study was to compare the faces of these children, emphasizing particularly variations in facial depth in relation to the type of occlusion.

Material and Method

Two groups each of thirty-six white children, 8 to 10 years of age, with non-mutilated dentitions, were selected from primary schools in Dunedin, New Zealand. The children with Class II, division 1 malocclusion were included in the Class II group: the others, having "normal" occlusion, formed the control group.

The lateral head radiographs of all seventy-two children were taken with a Margolis cephalostat with the teeth in

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occlusion. The necessary radiographic outlines were traced in the usual manner. For the location of different landmarks, the definitions given by Brodie[6], Downs[10], and Björk[4] were used. A specially constructed glass scale made it possible to read linear measurements from each tracing directly in true millimeters (Fig. 1).

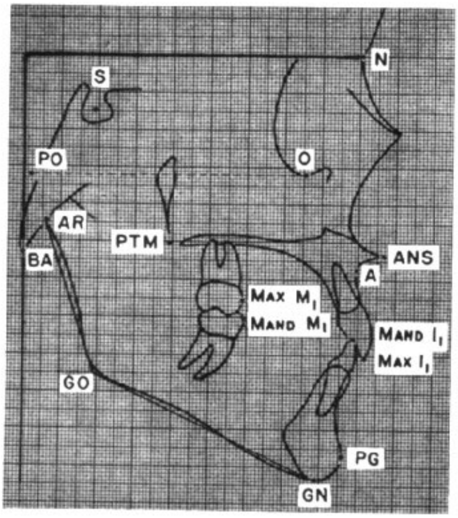

Fig. 1 Orientation of a tracing on the specially constructed millimeter scale for the coordinate method of cephalometric analysis used in this study. One millimeter on this scale is enlarged to the same extent as a given distance in the midsagittal plane of the head is enlarged on the radiographic film. The locations of the various cephalometric points are also shown.

In order to construct this scale, millimeter graph paper with accentuated centimeter lines was drymounted on a piece of thick cardboard which in turn was firmly attached to a bench. Fine stainless steel wires were stretched along the horizontal and vertical centimeter lines and kept in place with scotch tape. The resulting stainless steel wire mesh was placed in the midline of the Margolis cephalostat, corresponding to the position of the midsagittal plane of the head, and radiographed.

Transferral of the undistorted but slightly enlarged centimeter squares from the radiograph onto the glass plate was complicated by the need to obtain millimeter divisions within the centimeter squares.

On the radiograph of enlarged centimeter squares, a standard series of squares having 10 divisions per side was "fitted" by image projection. By removing the radiograph and in its place exposing a photographic glass plate to the fitted image, a permanent scale duplicating the enlarged millimeter squares was obtained. Thus, a millimeter on the scale was enlarged to the same extent as a given distance in the midsagittal plane is enlarged on a radiographic film since the midsagittal plane-film distance is constant in the Margolis cephalostat.

Any distance between two landmarks in the midsagittal plane of the subjects studied could now be read directly from a tracing placed on the glass scale. All readings were in actual millimeters and the error incurred was less than one per cent.

This technique also permitted the measurement of the distance between two given points, one of which was outside the midsagittal plane. Measurement of the length of the mandible between articulare and pogonion may serve to illustrate this point. The shadows of the left and right sides of the mandible are never actually superimposed on cephalometric radiographs. If mandibular length is measured separately on right and left sides, the distance between articulare and pogonion will be less on the side closer to the film (left) and greater on the opposite side because the millimeter scale compensates for radiographic enlargement only at a specific object-film distance, the object in this case being the midsagittal plane. However, when the midpoint between the two

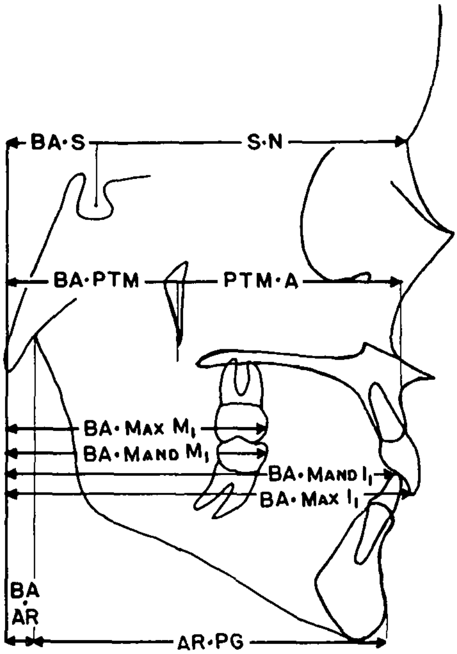

Fig. 2 Analysis of craniofacial depth.

registrations of articulare is taken, the average distance between pogonion and the left and right articulate points is obtained.

Tracings of the cephalometric radiographs were orientated on the glass scale in such a manner that one horizontal line passed through nasion, parallel to the Frankfort horizontal line (the nasion-parallel plane of Krogman[16]), and one vertical line passed through basion. These lines are abscissa and ordinate of the coordinate system (Fig. 1).

Cranial and facial depths were measured as *projections* on nasion-parallel, as follows (Fig. 2):

1. Cranial Base
   - Ba - N: total length of cranial base
   - S - N: anterior component of cranial base
   - Ba - S: posterior component of cranial base
2. Upper Face
   - Ba - A: total upper facial depth
   - Ba - Ptm: distance between maxilla and posterior limit of cranial base
   - Ptm - A: maxillary length
3. Lower Face
   - Ba - Pg: total lower facial depth
   - Ba - Ar: distance between mandible and posterior limit of cranial base
   - Ar - Pg: mandibular length

Anterior and posterior facial heights were measured as projections on the ordinate perpendicular to nasion-parallel as follows (Fig. 3):

1. Anterior Facial Height
   - N - Gn: total anterior facial height
   - N - ANS: upper anterior facial height
   - ANS - Gn: lower anterior facial height
2. N - Go: total posterior facial height
   - N - Ar: upper posterior facial height
   - Ar - Go: lower posterior facial height

In order to determine the horizontal relationships of the dental arches to the posterior limit of the cranial base, the projected distances from basion to the mesial surfaces of the permanent maxillary and mandibular first molars on nasion-parallel (N//) were measured (Ba-M_1max., and Ba-M_1mand.) (Fig. 2). The distance between the incisal margins of the maxillary and mandibular central incisors in the sagittal plane (overjet) and in the vertical plane (overbite) were obtained indirectly as follows (Fig. 3):

1. Overjet
   Ba-I_1max. minus Ba-I_1mand., as projected on the abscissa
2. Overbite
   N// - I_1max. minus N// - I_1 mand., as projected on the ordinate

The facial angle (N-Pg-N//) and the

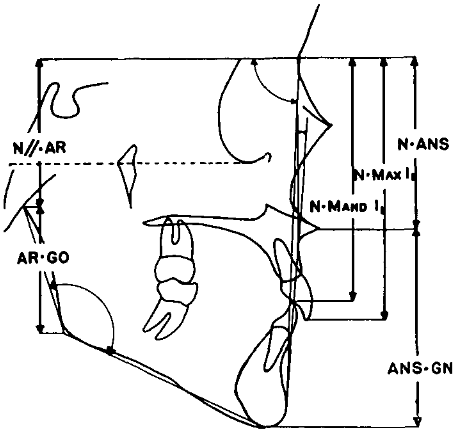

Fig. 3 Analysis of craniofacial height and the angles measured.

angle of convexity (N-A-Pg), both descriptive of the bony profile according to Downs[10], were obtained in each instance (Fig. 3). The gonial angle (Ar-Go-Gn) and the Frankfort mandibular plane angle (FH-Go-Gn) were the only other angular measurements made.

The data for each sample were analyzed statistically. The mean, standard deviation, and range of each measurement were determined. The difference between the means for the groups was statistically significant when the Critical Ratio was equal to or greater than 2.5 (C.R. = >2.5), and the probability equal to or less than 0.05 (p = <0.05).

The sex ratios for the two samples of children were not identical. Since statistically significant differences between a few mean values of males and females were observed within the Class II and control groups, it was necessary to compute weighted means and standard errors of the means in order to draw valid conclusions from the findings when comparing children having normal occlusion and Class II, division 1 malocclusion.

Findings

The means, standard deviations, and levels of statistical significance between means are presented in Table I. Unless stated otherwise, all differences mentioned in the following report of the findings are statistically significant.

Facial depth (Table I and Figure 4)

Cranial Base. Compared to the control group, the Class II group has a greater mean total cranial base length (C.R. 3.5) as well as a longer posterior component (C.R. 2.8).

Upper Face. The mean total facial depth (Ba-A) is greater in the Class II group than in the control group, but this difference is not statistically significant. The difference between the groups for the horizontal distance from maxilla to basion (Ba-Ptm) approaches statistical significance (C.R. 2.4).

Lower Face. Average mandibular length (Ar-Pg) is short in the Class II group (C.R. 2.9). Although the distance Ba-Ar is small, it is significantly

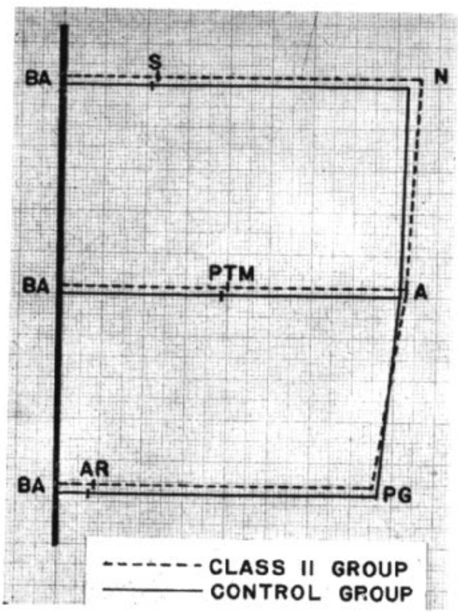

Fig. 4 Mean projected craniofacial depths of 36 children with normal occlusion (control group) and 36 children with Class II, division 1 malocclusion (Class II group). Age range 8-10 years.

TABLE I

Craniofacial dimensions measured as projections on a coordinate system, and angular measurements of 36 children with normal occlusion (Control group) and 36 children with Class II, division 1 malocclusion (Class II group), aged 8-10 years.

		Control Group		*Class II Group*			
Variate		*Mean*	*S.D.*	*Mean*	*S.D.*	*C.R.*	*p*
Cranial Base Length	Ba-S	21.0 mm	2.59	22.5 mm	1.97	2.8	$.001 < p < .01$
	S-N	61.0	3.55	62.8	2.90	2.4	$.01 < p < .02$
	Ba-N	82.2	4.03	85.1	3.08	3.5	$p < .001$
Upper Facial Depth	Ba-Ptm	38.5	2.66	39.8	2.20	2.4	$.01 < p < .02$
	Ptm-A	42.5	1.75	43.2	2.10	1.5	$.14 < p < .15$
	Ba-A	81.0	3.44	82.8	3.68	2.2	$.03 < p < .04$
Lower Facial Depth	Ba-Ar	7.7	1.49	8.7	1.48	3.0	$.001 < p < .01$
	Ar-Pg	68.8	3.87	65.7	5.22	2.9	$.001 < p < .01$
	Ba-Pg	76.8	4.20	74.5	5.16	2.1	$.03 < p < .04$
Anterior Facial Height	N//-ANS	44.5	2.33	45.2	2.21	1.3	$.19 < p < .20$
	ANS-Gn	55.4	3.12	54.7	3.95	0.8	$.40 < p < .41$
	N//-Gn	99.3	6.73	99.9	4.70	0.4	$.65 < p < .66$
Posterior Facial Height	N//-Ar	35.4	3.58	37.2	4.21	2.0	$.04 < p < .05$
	Ar-Go	37.1	2.54	36.9	2.89	0.4	$.68 < p < .69$
	N//-Go	72.5	3.27	74.2	4.74	1.7	$.08 < p < .09$
Relation of Dentition to Cranial Base	Ba-Max.M^1	55.5	3.74	56.8	3.21	1.5	$.12 < p < .13$
	Ba-Max.I^1	82.6	3.84	85.0	4.91	2.3	$.01 < p < .02$
	Ba-Mand.M^1	55.5	4.13	53.8	3.66	1.9	$.06 < p < .07$
	Ba-Mand.I^1	80.3	3.77	78.5	4.33	1.8	$.07 < p < .08$
Overbite	N//-Max.I^1 ...... minus N//-Man.I^1	3.4	2.02	5.9	2.01	5.4	$p < .001$
Overjet	Ba-Max.I^1 ...... minus Ba-Mand.I^1	2.4 mm	0.63	6.5 mm	3.56	6.9	$p < .001$
Facial	N-Pg-N//	86.5°	2.63°	83.7°	3.55°	3.9	$p < .001$
Convexity	N-A-Pg	+4.5°	3.77°	+9.8°	4.22°	5.6	$p < .001$
Gonial	Ar-Go-Gn	126.6°	5.76°	124.4°	5.23°	1.7	$.08 < p < .09$
Mand. Plane	Go-Gn-N//	25.7°	3.81°	24.7°	5.60°	0.8	$.40 < p < .41$

larger in the Class II group than in the control group (C.R. 3.0). In view of the similarity in the values for the gonial and mandibular plane angles, it seems that the mandible is in an anterior position in relation to the posterior limit of the cranial base in Class II, division 1 malocclusion. An analysis by the author of data on two patients reported by Coben[8] gave a similar finding. The difference between the average total lower facial depths (Ba-Pg) in the two groups of children is not statistically significant (C.R. 2.1).

Facial height (Table I)

Anterior Facial Height. Mean values for upper, lower, and total anterior facial heights are similar in the two groups. This is borne out by the close approximation of the percentage ratios of upper to lower anterior facial heights in the control 44.6 : 55.4 and Class II groups (45.3 : 54.7). The latter finding conforms closely to that given by Wylie[23] for individuals with malocclusion of all types (45.8 : 54.2).

Posterior Facial Height. There are no statistically significant differences between the mean values pertaining to this dimension.

Relationship of dentition to cranial base (Table I)

The average distances from basion to the permanent maxillary and mandibular first molars are similar in the two groups. The difference between the average distances from basion to the mandibular central incisor (Ba-Mand. I_1) is not statistically significant (C.R. 1.8). However, in the average child with Class II, division 1 malocclusion the maxillary central incisor is in a more forward position as measured from basion (Ba-max.I_1) than in an average child with normal occlusion. This is the only difference between measurements relating the dentition to the cranial base that approaches statistical significance (C.R. 2.3).

As expected, overbite and overjet are considerably larger in children with Class II, division 1 malocclusion than in those with normal occlusion (C.R. 5.4 and 6.9, respectively).

Angles (Table I and Figure 4)

The facial angle was significantly small (C.R. 3.9) in the Class II group. The mean value for the angle of convexity in the Class II group was twice that of the control group (C.R. 5.6). The gonial and mandibular plane angles showed no statistically significant differences between the two groups of children.

The above conclusions derived from group statistics show their limitations when applied to individuals. This was evident when three children of the Class II group (Table III), with the greatest depth of the cranial base and

TABLE II

Data for a child of the control group (R12) whose craniofacial dimensions correspond closest to the mean data for that group, according to the method of analysis used in this study. (This child's tracing was chosen to represent the "average" face of the control group).

Variate		*R12*	*Mean, Control Group*
Cranial Base Length	Ba-S	18.0 mm	21.0 mm
	S-N	63.0	61.0
	Ba-N	81.0	82.2
Upper Facial Depth	Ba-Ptm	35.5	38.5
	Ptm-A	44.0	42.5
	Ba-A	79.5	81.0
Lower Facial Depth	Ba-Ar	6.0	7.7
	Ar-Pg	69.0	68.8
	Ba-Pg	75.0	76.8
Anterior Facial Height	N-Gn	102.0	99.3
Posterior Facial Height	N//-Go	76.5	72.5
Overbite		4.5	3.4
Overjet		1.5 mm	2.4 mm
Facial Angle		86.5°	86.5°
Angle Convexity		+5.5°	+4.5°
Gonial Angle		131.5°	126.6°
Mand. Plane Angle		26.0°	25.7°

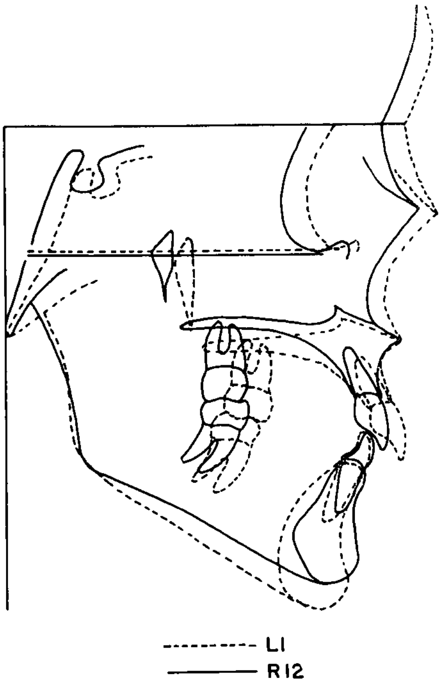

Fig. 5 Tracing of a child with Class II, division 1 malocclusion (L1) having the greatest depth of the cranial base within the Class II group, superimposed on a tracing (R12) representing the average face of the control group.

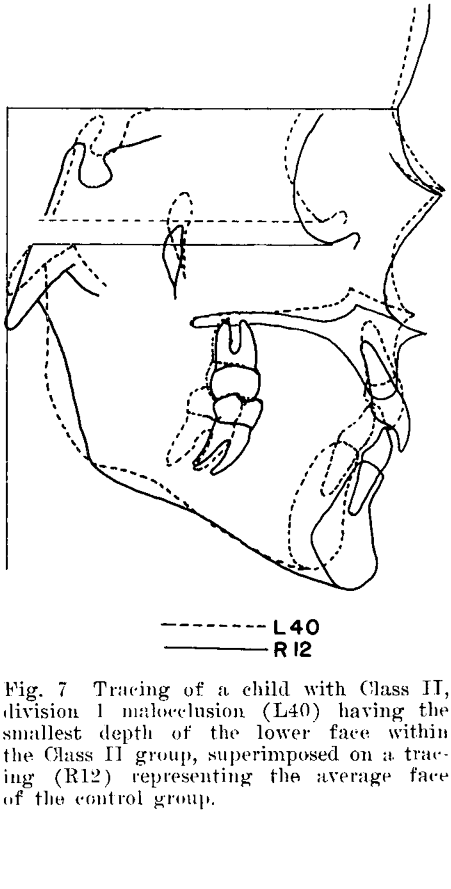

Fig. 7 Tracing of a child with Class II, division 1 malocclusion (L40) having the smallest depth of the lower face within the Class II group, superimposed on a tracing (R12) representing the average face of the control group.

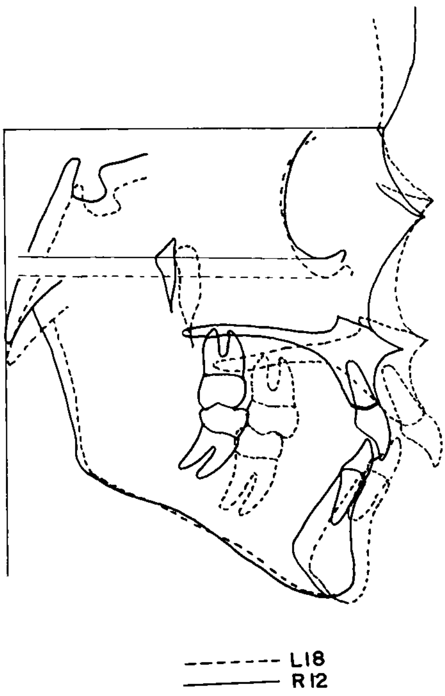

Fig. 6 Tracing of a child with Class II, division 1 malocclusion (L18) having the greatest depth of the upper face within the Class II group, superimposed on a tracing (R12) representing the average face of the control group.

upper face (L1 and L18, respectively) and with least depth of the lower face (L40), were compared with the "average" face of the control group. One child with normal occlusion (R12, Table II) was chosen to represent this "average" face since his facial dimensions corresponded closest to the mean values for the control group.

Tracings of the lateral head radiographs of L1, L18, and L40 are superimposed upon a tracing of R12 in Figs. 5, 6, and 7 respectively. The coordinate system used in this study served as the method of superimposition. Each of the three tracings was superimposed upon that of R12 along nasion-parallel and its perpendicular through basion. The intersection of the two coordinates became the point of registration. Although deviations in depth constitute the major point of interest in this discussion, overall variations in facial configuration, at least from the lateral aspect, are illustrated.

L1 typifies the facial form associated with Class II, division 1 malocclusion according to the statistical findings of the present study (Fig. 5); L18 has a marked maxillary protrusion (Fig. 6); L40 exemplifies the facial form traditionally associated with Class II, division 1 malocclusion (Fig. 7). These comparisons illustrate the wide range of facial configurations which occur among individuals with this type of malocclusion. The variability at the three planes of facial depth, namely at the level of the cranial base, upper and lower face, is particularly striking.

Discussion

Generally speaking the mandible is shorter than average in Class II, division 1 malocclusion (Craig[9], Drelich[11], Gilmore[15], Nelson and Higley[19], and Reidel[20]), and this is confirmed by

TABLE III

Craniofacial dimensions of children with Class II, division 1 malocclusions and the mean data for the control group. "L18" having the greatest depth of upper face, "L1" having the greatest length of the cranial base and "L40" having the least depth of the lower face.

Variate		*L18*	*L1*	*L40*	*Mean, Control Group*
Cranial	Ba-S	21.0 mm	21.0 mm	20.0 mm	21.0 mm
Base	S-N	60.0	66.0	60.5	61.0
Length	Ba-N	81.0	87.0	80.5	82.2
Upper	Ba-Ptm	41.5	41.0	37.0	38.5
Facial	Ptm-A	46.5	42.0	43.0	42.5
Depth	Ba-A	88.0	83.0	80.0	81.0
Lower	Ba-Ar	11.0	9.0	7.5	7.7
Facial	Ar-Pg	68.5	66.0	62.3	68.8
Depth	Ba-Pg	79.5	75.0	70.0	76.8
Anterior Facial Height	N-Gn	103.0	107.0	97.5	99.3
Posterior Facial Height	N//-Go	74.5	78.0	71.0	72.5
Overbite		6.0	5.0	7.0	3.4
Overjet		7.5	7.5	3.0	2.4
Facial Angle		89.0°	83.5°	83.5°	86.5°
Angle Convexity		+17.5	+7.0	+13.0	+4.5
Gonial Angle		127.5	130.0	117.5	126.6
Mand. Plane Angle		21.5	28.5	25.0	25.7

the findings of the present study.

Gilmore[15] found that the posterior border of the mandibular ramus bears a similar relationship to the cranial base in excellent occlusion and Class II, division 1 malocclusion. According to the present study, however, the mandible is situated in a more anterior position in the latter relative to the posterior limit of the cranial base. The integration of these two components of lower facial depth, namely the shorter length of the mandible and its forward position, has a "cancelling out" effect in Class II, division 1 malocclusion leaving the chinpoint at virtually the same horizontal distance from basion as in normal occlusion.

The existence of a constant proportional relationship between the permanent mandibular first molars and the mandible in Class I and Class II malocclusions was proposed by Elman[12]. Using more refined statistics in a similar study Gilmore[15] showed conclusively that this relationship was not constant. The results of the present study do not support Elman's contentions, nor are they offered as positive confirmation of Gilmore's findings. Yet it must be admitted that the similarity in Ba-M_1 mand. measurements, the anterior position of the mandible, and its smaller length in the Class II group are indicative of some differences in the anteroposterior relationship of the permanent mandibular first molar to the mandible in normal occlusion and Class II, division 1 malocclusion.

Baldridge[2,3] stated that the permanent maxillary first molar maintains the same relationship to the face and cranium in Class I and Class II malocclusions. At first glance the results of the present study substantiate this claim since the permanent maxillary first molars are located at similar distances from basion in both the control and Class II groups. However, when the longer cranial base and the anterior position of the maxilla are taken into consideration, it is evident that the relationship of these teeth to the face and cranium may vary according to the type of occlusion.

Although overjet and overbite received relatively little attention in the present study, two aspects of the findings are worthy of comment. First, there is some indication that the large overjet in Class II, division 1 malocclusion is determined by the position of the upper central incisor (C.R. 2.3) rather than by the lower one (C.R. 1.8). Secondly, the association between larger overbite and unchanged anterior facial height in the Class II group does not differ significantly from zero ($r = -0.158$). This finding is at variance with Wylie's[24] observation that individuals with severe overbite have a shorter lower anterior facial height than those with slight overbite.

The overall depth of the upper face was similar for children with normal occlusion and those with Class II, division 1 malocclusion. Ptm-A, one of the two variables constituting the horizontal distance from point A to the posterior limit of the cranial base, did not differ in the two groups. The other variable, Ba-Ptm, was larger in the Class II group, the difference almost reaching statistical significance (C.R. 2.4). These findings suggest that, when Class II, division 1 malocclusion prevails, the depth of the upper face might be influenced more by a change in the horizontal relationship of the maxilla to the posterior limit of the cranial base, than by an increase in maxillary length.

The greater depth of the cranial base in the Class II group is attributed to an increase in its effective length. There are three possible explanations for this change. First, there could be an increase in the actual lengths of the anterior or posterior components of the cranial base as suggested by Björk[4] but not verified by Craig[9] or Gilmore[15]. Secondly, an increase in the effective length of the cranial base could be related to changes in its flexure (Björk[4], Lindegärd[17]). Thirdly, there is the possibility of a change in the spatial relationship of the cranial base to the Frankfort horizontal plane, due to positional variations either in this plane or in the cranial base. According to Craig[9], however, the anterior and posterior cranial bases lie at practically the same angle to the Frankfort horizontal plane in Class II, division 1 malocclusion and excellent occlusion.

The use of the facial angle to describe variations in the depth of the lower face presupposes the relative stability of nasion and, therefore, similarity of the effective lengths of the cranial base in normal occlusion and Class II, division 1 malocclusion. In terms of the findings of the present study it is conceivable that the facial angle is smaller in the Class II group because nasion is situated anteriorly (C.R. 3.5) while the position of pogonion is less affected (C.R. 2.1).

In the present study only one (nasion) of the three profile points (nasion, point A, and pogonion) differed to a statistically significant degree in its horizontal relationship to the posterior limit of the cranial base. However, among individuals, variations at all three levels of craniofacial depth were responsible for the greater convexity of the profile in children with Class II, division 1 malocclusion.

The mean findings suggest that the typical face of children with Class II, division 1 malocclusion differs from previous concepts, including that of Angle. Average findings or a generalized concept of type *cannot* be applied to the individual inasmuch as each child is typical for himself. This fact is of great importance in orthodontic diagnosis and treatment planning.

Summary

A cephalometric radiographic appraisal was made of thirty-six children with Class II, division 1 malocclusion and a similar number having normal occlusion. All children were between eight and ten years of age.

To facilitate the coordinate method of analysis utilized in this study, a glass scale was used to measure tracings from lateral head radiographs.

The facial form of children with Class II, division 1 malocclusion was resolved at three levels of craniofacial depth. In terms of the mean findings, the typical facial configuration of these children was expressed as an increase in the effective length of the cranial base, concomitant with similar depths of the upper and lower face.

As an important aspect of this study, namely that of individual variation, three children with Class II, division 1 malocclusion illustrated: (1) the individuality in facial configuration of children grouped according to class of malocclusion, (2) three typical, but different variants of the facial form associated with this malocclusion, (3) the limitations of applying group data to individuals particularly for the purpose of clinical evaluation.

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