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A Cephalometric Study of Cranial Base Morphology

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A CEPHALOMETRIC STUDY OF CRANIAL BASE MORPHOLOGY

by

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LIFE

Laurence I. Carlsen, Jr., was born in San Francisco, California, July 20, 1931.

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From 1962 to 1966 the author attended the Loyola University Dental School, and was awarded the Degree of Doctor of Dental Surgery in June, 1966. He began his graduate studies at Loyola University the same year.

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CHAPTER I

INTRODUCTION

The problem in the assessment of any malocclusion is to find the causitive factors involved. The entire plan of treatment and the patient's future dental health depends on recognition of the existing abnormalities. An accurate diagnosis still remains as the venerable corner stone in building function and stability into the correction of malocclusions. Each malocclusion must of necessity be evaluated individually, however, certain guidelines can and must be utilized as a basis for the evaluation.

In the early years of orthodontics the orthodontist directed his attention only to the teeth and the manner of their interdigitation. Now, through the process of diagnostic maturation, he has come to realize that the teeth are an integral part of the cranio-facial complex.

Although the significance of the cranial base has long been recognized by biological workers, it is only in recent years that the orthodontist has become aware of its significance. Modifications in the form and proportions of the cranial base are held to be the reflection of adaptive changes that have occurred between the brain case and the face.

The growth of the mandible must be integrated with that of both the anterior and the posterior cranial base. Since the mandible articulates with the glenoid fossa of the temporal bone, it is intimately influenced by the downward and backward growth of the posterior cranial base.

This study will attempt to assess cranial base morphology and its relationship to malocclusion.

CHAPTER II

REVIEW OF THE LITERATURE

> "Almost entirely the orthodontist is an applied morphologist; he is confronted with variations in physical constitution, and he does what he can to modify them in a favorable direction. If we are to understand the biologic basis of orthodontia, we must grasp the fundamental difference between which we may facetiously state as follows: The difference between the Shape you are and the Shape You're in." Wendle L. Wylie.

A review of the literature revealed little information that considered cranial base morphology as we are attempting to evaluate it, that is, from the standpoint of dental malocclusion, as defined by Angle. Numerous works in the past have concerned themselves with the development and growth of the cranial base and how it relates to craniofacial morphology.

Recent anatomical research points toward the cranial base as an important region concerned with the growth of the neural and facial skeletons. That there is a correlation between the cranial base flexure and the growth of the neural and facial skeletons is more recently indicated by Bjork (1955) and Lindegard (1952).

It is well to remember that the basi-cranial region of the human skull base exhibits a characteristic flexure. The axis, about which the bending occurs, passes transversely through the body of the sphenoid bone, dividing the skull base into pre- and post-sella components. A further topographic distinction is the delimitation of the neural and facial skeletons by the skull bone. It would follow then that a change in the form or position of the components of the sphenoid complex will greatly influence the angular relations of the skull base. This will also effect the maturation of both the neural and facial skeletons.

Bolk (1922) felt that the cranial base was adapted to the size and form of the brain. He considered the foramen magnum and the occipital condyles to be the more fixed points of the cranial capsule. His work reveals that the more central position of the cranial base in man was the position characteristic for the preservation of the fetal state. He also believed that the foramen magnum and the occipital condyles were shifted backwards in postnatal life.

A number of investigators have made cross-sectional studies of the change in the cranial base with age. Virchow (1924) designated the angle formed by the clivus and planum ethmoidal as the "saddle angle", claiming this angle decreased from birth to puberty.

Keith and Campion (1922) were among the first to attempt to study quantitatively the growth of the cranial base in the human skull. Using a series of skulls, they suggested that the increase in size can occur at three sutures, namely, the spheno-occipital, the spheno-ethmoidal and the fronto-nasal. They found the amount of growth at the fronto-ethmoidal suture was very restricted. The spheno-ethmoidal junction was concerned not only with the growth of the face, but also with the increase of the brain case. Growth at the spheno-occipital junction permitted enlargement of the brain and backward movement of the auditory meatus. In this way, space was provided for the growth of the mandible and pharynx.

In 1937, Broadbent, the developer of cephalometric roentgenography, suggested that certain planes in the head were more suitable for the purpose of serial comparison of the same and of different individuals than those commonly used at the time. All of these lay in the zone of the junction between the cranium and the face. Among others, he mentioned S-N (center of sella turcica to fronto-nasal junction) and S-B (center of sella turcica to the Bolton point). Since that time, the angle N-S-B has been employed by a number of investigators as the cranial base angle.

Brodie (1941), using cephalometric roentgenology for serial studies, measured the cranial base by dividing it into four parts. These divisions were: (1) center of sella turcica to the Bolton point, (2) center of sella turcica to the spheno-occipital junction, (3) center of sella turcica to nasion and (4) center of sella turcica to the spheno-ethnoidal junction. From these measurements, he concluded that the anterior cranial base at three months was longer than the posterior portion; but that post-natal growth of the two was almost equal. After one and one-half years, the growth of the various segments comprising the cranial base seemed to maintain the same relative size. Neither the absolute size nor the relative proportions of the cranial base were shown to have an influence on facial type.

Bjork (1947) studied the facial profiles of Swedish boys and conscripts, measuring the angle formed between nasion, sella turcica, and articulare, and found that this angle opened in some individuals and closed in others. This angle was then related to the degree of prognathism in the face.

Brodie (1951) measured the angle formed by Bolton point, sella turcica, and nasion, and found that this angle remained unchanged in half of his cases and increased or decreased in the rest.

One of the most exemplary researchers on the problems of facial growth, cranial base growth and malocclusion is Arne Bjork. In his study on cranial base development (1955), he favors the premise that the cranial base is obliged to develop in conformity with the brain and facial structures. This means it must follow two different growth rates: one on the internal surface and one on the external surface. Since the face, both upper and lower, will continue to grow until age eighteen to twenty in females, and twenty to twenty-four in males, the sutural growth in the cranial base will remain active to a greater or lesser degree in order to compensate for these changes. This occurs in spite of the fact that the cranial development has ceased at approximately the twelfth year of life.

Flexion of the cranial base occurs until age ten to twelve, and then becomes constant, but individual variations do occur and can be quite marked. Age changes in the cranial base form are proportional to those calculated within the facial structures. He states at this time that, although individual variations may be great, the mean change that takes place with age will be relatively small.

Bjork, in his first major study in 1947, brought one of the first significant assessments of cranio-facial morphology with a direct view at the role played by the cranial base. His study was conducted on 322 twelve-year old boys and 281 Swedish conscripts. With this group he attempted to analyze the nature of prognathism. Of the conscript group, he found that normal occlusion was more frequently found in the prognathic group and this was statistically significant. Conversely, crowding occurs more often in the less prognathic individual.

His studies on the twelve-year old boys revealed basically the same information. The significant angular findings were: with the growth the degree of mandibular prognathism increases, but there is a tendency for this to be equalized by a decrease in the chin angle.

Reidel (1948), in his master's thesis, studied the relation of the maxilla and its associated parts to the cranial base in normal occlusion and malocclusion. His study resulted in the following conclusions: There was no significant difference in the anterio-posterior relation of the maxilla to the cranial base in patients presenting excellent occlusion and malocclusion of the teeth. There was evidence of a tendency for the maxilla to become more prognathic with growth in his sample. The antero-posterior relation of the mandible to the cranial base was found to be significantly different in patients exhibiting excellent occlusion when they were compared to individuals possessing malocclusions.

Bjork (1950), in an article titled, "Biological Aspects of Prognathism and Occlusion of the Teeth", brings forth one of the strongest reasons for evaluating facial morphology from the cranial base, (he will use what he calls the effective cranial base, viz., a line from nasion to either articulare or Basion). Although he considered the use of the Frankfort Plane, because of the greater variation in the cranial base plane, he felt that the Frankfort Plane was to be avoided because it passes through the face. Therefore, orienting facial structures to a facial plane compounds the problem because the plane of orientation is subject to the same variation as the rest of the facial skeleton.

In discussing prognathism, which he defines as the prominence of the facial skeleton in relation to the cranial base, he goes on to conjecture what may bring about a prognathic situation. These are: (1) A shortening of the cranial base, (2) A decrease in the saddle angle, (3) A decrease of the articular angle (therefore, a more forward inclination of the ramus), (4) An increase in jaw length in relation to the cranial base, as a whole.

He declares that individual facial prognathism mainly depends upon the formation of the cranial base and that the rate of increase of prognathism is greater during the latter years of adolescence. This is in keeping with the fact that the cranial base development is concluded earlier than the jaws, especially the mandible. This serves to straighten the facial profile. Alveolar prognathism was found to develop slower than basal prognathism, which causes the incisors to upright and the chin to become more pointed. Because of this, crowding of the incisors will result.

This study reaffirmed his opinion that proportional growth changes are not constant, but appear to vary from individual to individual. He also observed that the correlation between maxillary and mandibular prognathism appears to diminish as a result of racial mixture.

Blair (1952), in a cephalometric appraisal of the skeletal morphology of forty Class I, twenty Class II Div. 1, twenty Class II, Div. 2, Angle malocclusions, formed a number of observations which are pertinent to this study. Contrary to previous observers, he found no significant difference, except for size, between male and female. This, he felt, should allow future orthodontists to group subjects regardless of sex when doing angular measurements.

Statistically comparing the Class I malocclusions to the Class II, Blair found the Class I patient had a greater gonial and a more acute chin angle (as formed by the mandibular plane and the N-P plane). This resulted in these patients having a higher Y-axis (Nasion-sella turcica-gnathion) and a more "effective" length (this is determined by the distance from the head of the condyle to gnathion). The Class II, Div. 2, patients were found to have a larger chin angle and a more prognathic maxillary base (S-N-A). Maxillary prognathism (S-N-A) was seen to be directly correlated with mandibular prognathism (S-N-B), and both are inversely correlated with the angle (Nasion-sella-articulare). The saddle angle was also found to be inversely correlated with the joint angle (Sella-articulare-gonion).

Blair, like many since, has stressed the theme of individual variability, warning future researchers to be careful when assessing inverse proportions, so as not to infer that a "compensatory variation" exists.

Lindegard (1952), using osteological material, studied the upper alveolar process and its relation to the cranial base. He reports that, as the angle of inclination of the alveolar plane increases, it moves under the cranial base. As a result of the process, he finds that the anterior portion of the alveolar plane moves downward and back, and the posterior portion of this same plane moves up and back. In effect, the maxillary incisor and cuspid teeth are displaced down and back and molar teeth up and back, the alveolar process pivoting, as it were, about the premolars.

Allan G. Brodie, Jr., in his master's thesis (1955), studied the cranial base by means of serial cephalometric roentgenograms. He divided the cranial base into three parts, viz., from Basion to the spheno-occipital junction (Ba-So), from the spheno-occipital junction to the spheno-ethmoidal junction (SO-SE), and from the spheno-ethmoidal junction to Nasion (SE-Na). In this study of midsagittal landmarks, the serial cephalometric roentgenograms were employed to measure the incremental growth of the cranial base and the relative contribution made by each part of the cranial base to the whole. The conclusions brought to our attentionin this study reveal that in any individual the relative constribution made by each part of the cranial base remained virtually constant throughout the period studied. The constribution for the posterior part (B-SO) was 25 per cent: for the sphenoidal part (SO-SE) it was 37 per cent: and for the anterior part (SE-Na) it was 38 per cent. This constancy in proportion was maintained in the entire group over the age range of three to eighteen years. It was also recognized that the pattern of incremental growth of the cranial base was characterized by rapid growth from birth to five years, deceleration between five and twelve years, with a plateauing between ten and thirteen years and then a gradual decrease to the point of growth completion. This work tended to confirm the results of A. Brodie in 1941.

Ricketts (1955), in an analysis of changes in the face and denture by investigating the temporo-mandibular joint, noted extremes of variation in the cranial base of patients before treatment. Points N, S, and Ba were connected and the cranial base angle was studied for changes. This measurement resembles somewhat the "Saddle angle" (NS-articular) described by Bjork. The average angle (NS-Ba) was noted to be 130 degrees and extremes were 121 and 141 degrees. He found that during treatment the average angular dimension showed no change, but individual cases were noted to become more acute or more obtuse by two degrees. Linear measurements between points sella and basion revealed a change of about one millimeter per year, although no change could be seen in many cases.

Braun and Schmidt (1956), using lateral cephalometric roentgenograms of a well defined cross-sectional sample of 100 Class I and Class II, division 1 malocclusions, studied the curve of spee, ramus height, gonial angle and mandible length in these two types of malocclusions, and they felt that the entire structure of the mandible could be exempt as a source of difference between Class I and Class II, division 1. They felt that the difference is either in the maxilla, the position of the maxilla and mandible to cranial base, the relative difference of maxilla to the curvature of spee, or a difference in the relative position of the maxilla to the mandible. In comparing sex differences between Class I and Class II, division 1 occlusions. They found that male mandibular length and ramus height to be significantly greater in males than in females.

Ricketts (1960), in a more recent investigation of serial cephalometric head films studied the cranial base, mandible, maxilla, teeth and soft tissue profile from the standpoint of growth. In comparing fifty Class I cases with fifty Class II cases, he found an average cranial base angle (NS-Ba) of 129.7 degrees in both groups thus substantiating his earlier findings. He summarized, on the basis of two hundred and fifty cases that the cranial base angle has a strong tendency to remain the same, that the sella nasion line increases generally at the rate of almost one millimeter per year and that the sella-basion increase is about three-fourths of that amount.

Schudy (1965), investigated growth changes which produce rotation of the mandible and the affects of orthodontic treatment on this rotation. He found that posterior vertical growth has the greatest influence on determining a vertical (clockwise) from a horizontal (counterclockwise) predominance of the growth pattern, which has a direct effect on the facial angle. The dorsal migration of the glenoid fossa, in close proximity to the posterior cranial base is a very real factor in many cases and tends to cancel out the growth of the condyles. Recognizing morphological differences between predominately vertical and conversely the predominate horizontal growth patterns in individuals during the diagnostic phase will play an important role in orthodontic therapy.

CHAPTER III

METHODS AND MATERIALS

A. Materials.

Random selection of the lateral cephalometric roentgenograms of fifty Class I malocclusions and fifty Class II malocclusions was made from the patient file of the Loyola University Orthodontic clinic. All cephalograms were taken prior to banding or separation. The racial extraction of all patients considered in this study was caucasian with mixed ethnic backgrounds.

The headfilms of patients with Class I malocclusions (Angle classification of first molars, and Class I canine relationship) consisted of twenty-three males and twenty-seven females with a mean age of 13 years and 4 months. The high being 18 years and 2 months and low being 10 years.

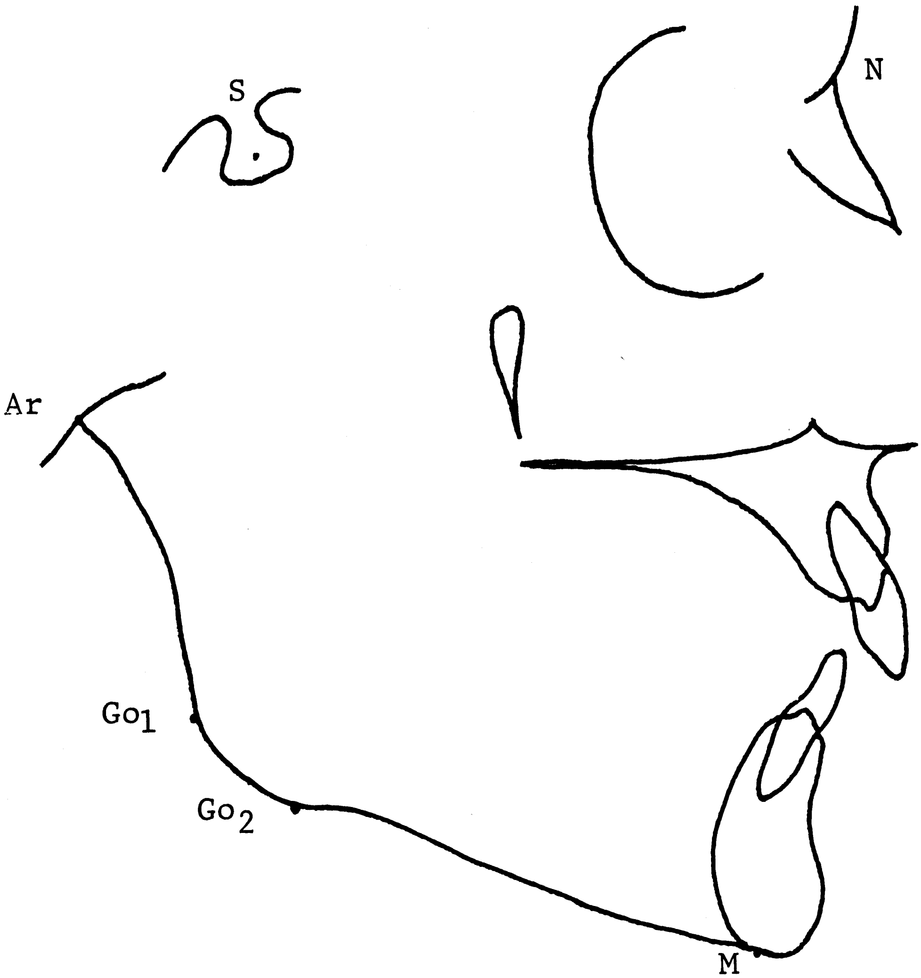
Of the fifty Class II patients, twenty-two were male and twenty-eight female. The mean age was 12 years and 7 months with a high of 15 years 7 months and a low of 10 years 1 month. These random samples were representative of the Loyola Orthodontic clinic patients.

B. Methods.

The roentgenographic technique employed was that described by Broadbent in 1931, in that the relation between the source of radiation, subject and film was standardized. The lateral head films of the patients, with their teeth in occlusion, were traced on acetate overlays.

Five landmarks were located and three angles were drawn and measured on these tracings. Only headplates with clearly defined landmarks were considered. If double images occurred, such as frequently occurs at the posterior border of the ramus, the mean difference between the two images was plotted and used. (Figure 1, Page 20).

All craniometric points and constructed points were located and measured twice at different times to eliminate and judge the element of human error. All linear measurements were recorded to the nearest one-half millimeter and



CEPHALOMETRIC LANDMARKS

FIGURE 1

angular measurements to the nearest one-half degree. If an error was found, then the particular measurement was remeasured and the necessary corrections were made.

C. Landmarks and Constructed Points.

Articulare (Ar) - The point at the junction of the external of the basis sphenoid and the posterior contour of the neck of the condylar process. The midpoint of the concyles was used when double projections gave rise to two points

Gonion (Go) - A constructed point formed by the intersection of the mandibular plane and the ramus plane. The midpoint was used where double projection gave rise to two points.

Gonion one (Go_1) - The most inferior point on the lower border of the body of the mandible at the gonial angle.

Gonion two (Go_2) - The most dorsal point on the posterior surface of the ramus at the gonial angle.

Nasion (N) - The most anterior point of the nasofrontal suture.

Sella (S) - The center of Sella Turcica (the midpoint of the horizontal diameter).

Menton (Me) - The lowermost point of the symphyial shadow.

D. Lines and Planes. (Figure 2, Page 23)

Mandibular plane - The line joining Menton (Me) and Gonion (Go_2).

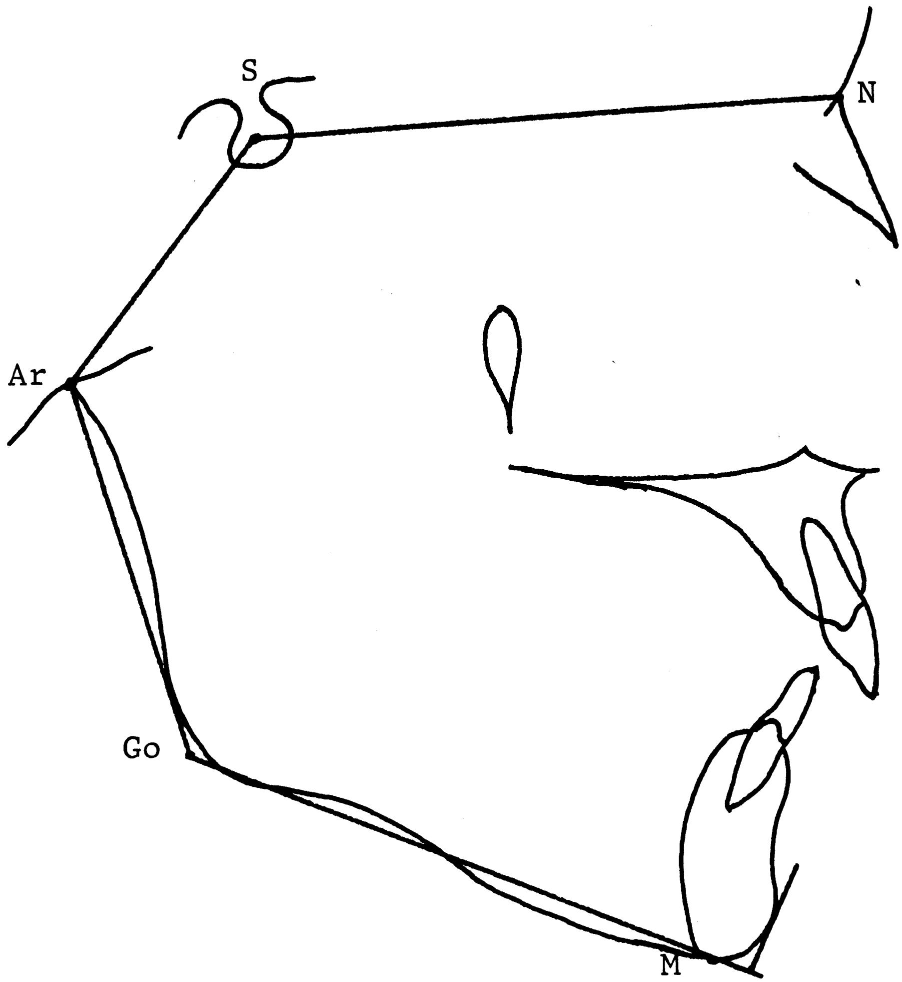
S-N Line - Line connecting point (S) representing the center of the sella turcica with (N) the frontonasal junction. This line denotes the anterior portion of the cranial base.

Ramus Line - A line intersecting Articulare (Ar) and tangent to the most posterior border of the ramus at the gonial angle (Go_1).

S-Ar Line - A line connecting point (S) with point (Ar). This line denotes the posterior portion of the cranial base.

E. Angular measurements.

All angles measured are the result of the plotting of three points on the intersection of two planes. Every plane mentioned in this investigation is at right angles to the film surface and is defined by two points in the plane



Demonstration of Angular and Linear Measurements

Figure 2

of the film. All angles were measured and recorded twice at separate times and compared for validity. Three angular relations were considered and they were as follows:

N-S-Ar - (saddle angle) The angle reflecting the relation of the anterior and posterior cranial base.

S-Ar-Go - The joint angle representing the relationship of the mandible to the cranial base when the teeth are in occlusion.

Ar-Go-Me - The gonial angle. (Figure 2, Page 23).

CHAPTER IV

FINDINGS

The statistical analysis of the three angular relationships plus the sum of the angles investigated in this study is represented in Table I. The mean values, standard deviations, and the normal range for the 95 per cent limits are denoted for the Class I and Class II population samples. Table II deals with the four linear relationships investigated. The Student "t" test was utilized for determining the significance between groups, and is depicted in Table III.

The findings were evaluated in the following manner. Values of "t" from 0.00 to 2.00 reveal that there is no significant difference between the compared values. Any "t" value of 2.00 or above falls with the 95 per cent confidence limits and is considered to be significant.

A. Comparison of angular values of Class I and

TABLE I

STATISTICAL EVALUATION OF ANGULAR MEASUREMENTS OF CLASS I AND CLASS II SUBJECTS

Measurement		Mean	Standard Deviation	95% Confidence Limit	
				high	low
Saddle Angle (degrees)	a)	123.54	4.89	133.32	113.76
	b)	125.16	5.63	136.42	113.90
Articular Angle (degrees)	a)	144.83	6.60	158.03	131.63
	b)	142.97	7.14	157.25	128.69
Gonial Angle (degrees)	a)	128.32	6.86	142.04	114.60
	b)	127.84	5.77	139.38	116.30
Sum (degrees)	a)	3.96.73	5.64	408.01	385.46
	b)	396.07	4.59	405.25	386.89

a) = Class I

b) = Class II

TABLE II

STATISTICAL EVALUATION OF LINEAR MEASUREMENTS
OF CLASS I AND CLASS II SUBJECTS

Measurement	Mean	Standard Deviation	Normal Range (95 %) high	Normal Range (95 %) low
Anterior Cranial Base (mm.)	a) 73.25	3.35	79.95	66.55
	b) 73.79	3.12	80.03	67.55
Posterior Cranial Base (mm.)	a) 35.14	3.86	42.86	27.42
	b) 35.18	3.62	43.42	27.94
Ramus Height (mm.)	a) 44.88	4.91	54.70	35.06
	b) 43.12	4.24	51.60	34.64
Body Length (mm.)	a) 77.08	4.38	85.84	68.32
	b) 75.38	4.82	85.02	65.74

a) = Class I

b) = Class II

TABLE III

"t" VALUES FOR CLASS I AND CLASS II

	"t"	Probability
Saddle Angle	1.528	$p > .10$
Articular Angle	1.34	$p > .10$
Gonial Angle	.378	$.40 > p > .35$
Sum	.651	$.35 > p > .20$
Posterior Cranial Base	.053	$p > .45$
Anterior Cranial Base	.831	$.45 > p > .40$
Ramus Height	1.89	$.35 > p > .20$
Body Length	1.62	$.10 > p > .05$

Class II means and standard deviations resulted in the following: (Table I, Page 26).

1. Saddle angle (N-S-Ar): The Class I mean (123.54) was found to be smaller than the Class II mean (125.16). The "t" value (1.528) falls between the 90 percent and 95 percent confidence limits and, therefore, there is not a significant difference between the two groups. (Table III, Page 28).

2. Articular Angle (S-Ar-Go): The Class I malocclusions (M=144.83) was larger than the Class II malocclusions (M=142.97).
This finding, with a "t" value of 1.34 reveals that the difference between the samples is not significant.

3. Angle Ar-Go-Gn (Gonial angle): This angle was found to be larger in Class I malocclusion cases (M=128.32) as compared to Class II cases (M=127.84). A "t" value of .378 reveals no significant difference between the groups.

4. Sum of the angles (Saddle, Articulare, Gonial): Comparing the values between the Class I (M=396.73) and Class II (M=396.07) samples denotes that they are not significantly different ("t"=.651).

B. Comparison of linear values between means and standard deviations of the Class I and Class II samples. (Table II, Page 27).

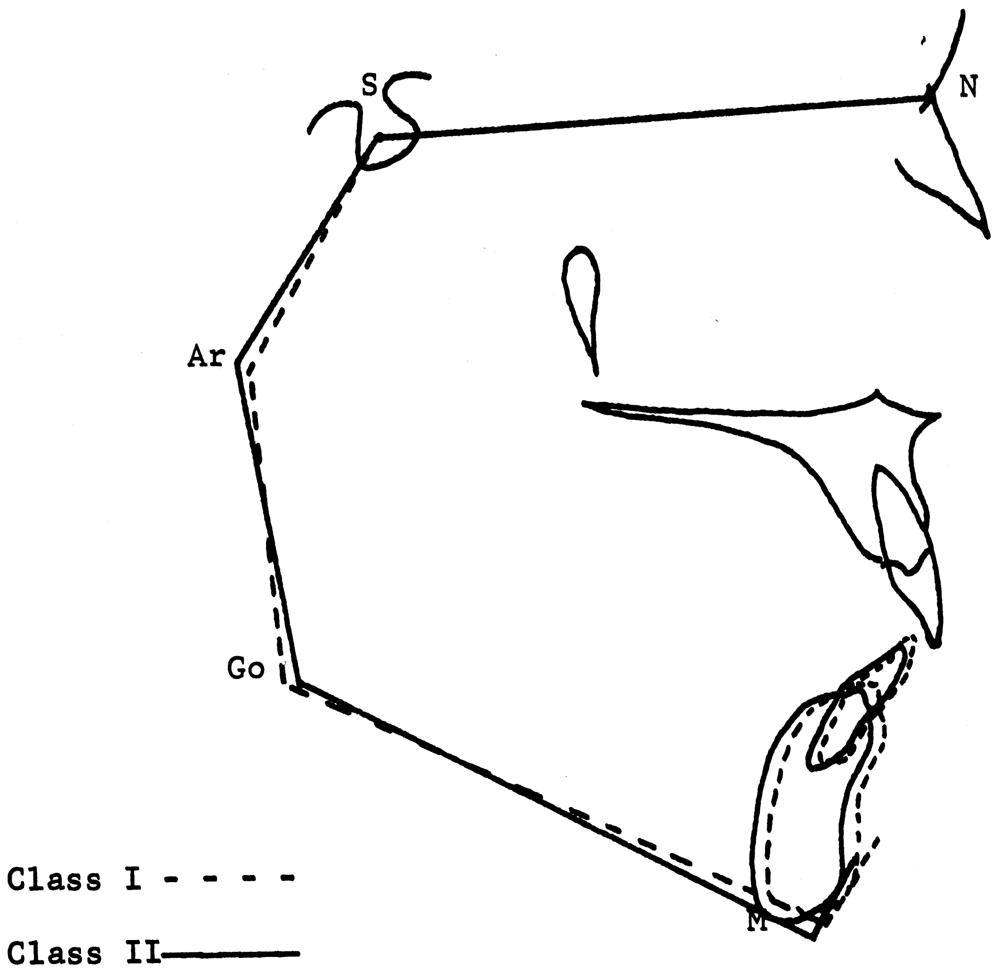
1. Anterior cranial base (S-N): The Class I mean (73.25) was found to be smaller than the Class II mean (73.79), however, there was not a significant difference between the values ("t"=.831).

2. Posterior cranial base (S-Ar): The Class I mean (35.14) is only slightly less than the Class II mean (35.18), and the "t" value (.053) reveals that there is no significant difference between the samples.

3. Ramus height (Ar-Go): This linear dimension was found to be larger in the Class I sample

(M=44.88) as compared to the Class II sample (M=43.12). A "t" value of 1.89 reveals no significant difference between these values.

4. Body length (Go-Po): Comparing the values between the Class I (M=77.08) and Class II (M=75.38) samples denotes that they are not significantly different ("t"=1.62). (Figure 3, Page 32).



COMPOSITE OF LINEAR AND ANGULAR MEASUREMENTS

Figure 3

CHAPTER V

DISCUSSION

A. The studies of Bjork have given the field of Orthodontics some interesting and valuable information. He has said that, "Shape is a function of growth which leads to the necessity for knowing the relationship between variations in shape and variations in growth" and also that, "coordinated variation in shape is an expression of the coordinated variation in growth". The variations of which he speaks, when evaluated for a group, will result in what is recognized as "mean values" for that group.

Evaluating these coordinated variations in shape for a group or population is most necessary. The status of disease or abnormality is based on what is normal for the species. The individual must be examined for, not so much how he may deviate from a statistical norm, but rather how well his individual variation in shape and growth has coordinated to produce a functioning entity. It is well to remember that the patient with malocclusion is an individual, with individual morphological problems, to which "means" are applied only as guidelines to facilitate proper assessment.

Hilgers (1961), in a prolific study on individual skeletal facial profile changes during growth utilizing serial cephalometric roentgenograms stated: "There are many different methods of studing dental and skeletal facial growth. Cephalometric roentgenography can be used to tell us how much growth there was; it may show us relative changes because of growth; but it does not tell us what kind of growth was and is taking place." He goes on to say: "Most dimensions for an individual will vary and few, if any, will be exactly the mean value. Causes of individual variation are hereditary, congenital, and environmental. It is factual that to produce anatomical balance of structures the dynamics of biological variability must balance the teeth, the muscles, and the bone within a single environment".

Bjork (1955), in his study on cranial base development points out that the cranial base, upper face and mandible grow until approximately the age of twenty. He also states that the dental and alveolar arches not only reflect the general growth tendency of the individual, but that in the case of malocclusions, certain secondary or modifying changes occurred. These modifications could be either dysplastic and/or compensatory. In studying these modifications, he found that the compensatory changes were more frequent during adolescence and that the dysplastic changes occurred earlier in life. The question that comes to mind, since the cranial base, mandible and upper face may grow until age twenty, is whether forces exerted to the jaws through the teeth, acting as biologic levers, can sufficiently affect the development of the cranial base? The cranial base as a hafting zone that separates the neural and facial skeleton, is said to be influenced by the growth of both elements. Dysplastic changes seem to be established earlier in life than compensatory changes; therefore, it does seem possible that, if a malocclusion were to approach a certain degree of severity, it would exert an influence on existing growth patterns, especially if this influence occurred early enough in life.

The angular changes of the posterior cranial base as pointed out by Bjork are those of sella turcica and articulare. Reduction of the angle at sella produces a forward positioning of the tempromandibular joint and forward displacement of the mandible with an increase in mandibular prognathism. Reduction of the articular angle brings the mandible upward and forward, decreasing the height of the upper face and increasing the degree of prognathism.

Changes in the linear dimension of the posterior cranial base also alters cranio-facial morphology. Shortening the line from sella to articulare shortens the posterior height of the face, and extreme shortening may result in open bite malocclusion. Increased facial height and reduction of prognathism is seen by lengthening the posterior cranial base.

B. Angular assessment of the posterior cranial base morphology of the Class I malocclusion, as it relates to Class II malocclusion.

Past investigators have revealed varied differences between Class I and Class II malocclusions. The most common observation was that the Class II, division 1 malocclusion had a tendency to have a more procumbent maxillary denture base, and that the mandible is more retrognathic in the Class II malocclusion. A third finding, upon which most researchers concurred, was that the Class I malocclusion has a more obtuse gonial angle. This observation led to their evaluating the Class II mandible as having a less effective or projected length than the Class I mandible. The facial complex of the Class II malocclusion was convex or retrognathic.

In assessing the information from this study, the observation can be made that the Class I and Class II samples presented some striking similarities. The most prominent of these was the seeming desire for the mean values of the cranio-facial complex to produce an equalization between the saddle and articular angles. The purpose of the "counter-balance" appears to be a need for the body to maintain a constancy in the cranial base and its relation to the gonial angle. For example, if we add the mean value for the saddle angle and the mean value for the joint angle of the Class I malocclusions, the following result was obtained: 123.54 + 144.83 = 268.37. Doing the same for the Class II malocclusions, the result is 125.16 + 142.97 = 268.13. This results in a difference of only 0.24 for the sums of the two means. The degree of similarity has led the author to feel that there appears to be a negating or equalizing effect between the two areas.

The mean values of the saddle angle in this study was larger in the Class II malocclusion, indicating a more distal positioning of the condylar fossa and the mandible at this point of reference as compared to the Class I malocclusions, however the difference was not significant.

The articular angle had a smaller mean value in the Class II malocclusions, however, not significantly different to be clearly defined as a real difference ("t"=1.34). Theoretically, the mean for the Class I sample was assessed as having a more posteriorly positioned chin and a greater cant to the mandibular plane when compared to the Class II sample.

The observation that the mean gonial angle of the Class I sample was larger than the Class II sample verifies the work Blair did, although a significant difference was not found in this study ("t"=.378).

In comparing the mean values for the sum of the saddle, articular, and gonial angles, another example of similarity was observed. The Class I sample (M=396.73) is only 0.66 greater than the Class II sample (M=396.07), further illustrating the constancy in posterior facial height between these two classes of malocclusion.

C. Linear assessment of the cranial base and the other linear measurements in this study.

The similarities seen in the angular values are apparent also in the linear values. Perhaps the mean values here are not a true picture, and that individual variability has been lost through statistical analysis of a random sample of malocclusions.

The posterior cranial base proved to be the most stable of any mean value. The Class I mean of (35.14 mm.) was only (0.04 mm.) smaller than the Class II mean of (35.18 mm.), and proved to be the least significantly different value of all values in this study ("t"=.053). This finding concurs with Brodie, Bjork and Rickotts, of the stability of the cranial base.

The anterior cranial base had a smaller mean value in the Class I malocclusions, however, not significantly different ("t"=.831). In theory, the greater length of the anterior cranial base in the Class II, creating a greater maxillary prognathism would account for the anterior position of the maxilla and the retrognathic facial profile characteristic of Class II malocclusions.

The ramus height mean was greater in the Class I sample, but a real significance was not apparent ("t"=1.89). Theoretically, a greater ramus length in Class I malocclusions is in accordance with Bjork in that an increase in the ramus height increases mandibular prognathism, and therefore, the' shorter ramus height in the Class II sample would comply with the retrognathic profile of Class II malocclusions.

The mandibular body length mean in this study was larger in the Class I malocclusions, but not significantly different.

Jarabak (1967), has stated that in "normal" skeletal patterns, the body length of the mandible approaches nearly a one to one ratio with that of the anterior cranial base. Examining the mean values of the Class I and Class II samples in this study reveals a mandibular body to anterior cranial base ratio of (77.08) to (73.25) or a (1.05) to (1) ratio in the Class I malocclusion, and a ratio of (75.38) to (73.79) or a (1.02) to (1) ratio in the Class II malocclusions. Therefore in this study it was found that the mandibular body length is somewhat greater than the length of the anterior cranial base.

The angular means and standard deviations in this investigation appear to verify and closely approximate those of Bjork in his study of facial prognathism in Swedish boys and conscripts. (Tables IV and V, Pages 42 and 43)

Comparison of the saddle angle indicates that only the Class II sample in this study was somewhat larger than Bjork's, while the articular angle was very nearly the same value.

The larger mean values for the saddle angle would account for a reduction of prognathism in Caucasians as compared to the more prognathic Swedish population.

TABLE IV

COMPARISON OF MEAN ANGULAR VALUES AND STANDARD DEVIATIONS TO THOSE OF BJORK

Measurement	Mean		Std. Dev.
Saddle Angle	Bjork	(a) 122.90	4.85
		(b) 123.06	5.33
	Exp. Gr.	(a) 123.54	4.89
		(b) 125.16	5.63
Articular Angle	Bjork	(a) 142.96	6.21
		(b) 143.27	6.91
	Exp. Gr.	(a) 144.83	6.60
		(b) 142.97	7.14
Gonial Angle	Bjork	(a) 131.09	6.11
		(b) 130.85	7.31
	Exp. Gr.	(a) 128.32	6.86
		(b) 127.84	5.77

Bjork (a) 12 yr. old boys (322 cases)
(b) 21 yr. old conscripts (281 cases)

Experimental Group (a) Class I sample
(b) Class II sample

TABLE V

COMPARISON OF MEAN LINEAR VALUES AND STANDARD DEVIATIONS TO THOSE OF BJORK

Measurement		Mean	Std. Dev.
Anterior Cranial Base	Bjork	(a) 68.75	2.97
		(b) 73.22	3.26
	Exp. Gr.	(a) 73.22	3.35
		(b) 73.79	3.12
Posterior Cranial Base	Bjork	(a) 34.35	2.85
		(b) 37.02	3.32
	Exp. Gr.	(a) 35.14	3.86
		(b) 35.18	3.62
Ramus Height	Bjork	(a) 42.13	3.60
		(b) 53.23	5.15
	Exp. Gr.	(a) 44.88	4.91
		(b) 43.12	4.24
Body Length	Bjork	(a) 72.84	4.12
		(b) 80.66	5.16
	Exp. Gr.	(a) 77.08	4.38
		(b) 75.38	4.82

Bjork (a) 12 yr. old boys (322 cases)
(b) 21 yr. old conscripts (281 cases)

Experimental Group (a) Class I sample
(b) Class II sample

The gonial angle was somewhat smaller in this investigation.

Evaluation of the linear comparisons, denotes a nearly similar anterior cranial base length in both Class I and Class II samples in this study, as that of Bjork's conscript sample.

The posterior cranial base length was shorter than his findings in the 21 year old conscript group, but greater than the 12 year old boys. Considering the chronological age group studied in this investigation, this evaluation appears to be logical.

The mean values of both the ramus height and body length also fell between the means of his 12 and 21 year old samples. This would also seem logical considering the age group investigated.

The findings in this study, denoting no significant difference between the Class I and Class II samples agree with those of Braun and Schmidt in that neither ramus height, gonial angle, nor mandible length were found to be different in size between Class I and Class II, Division 1 occlusions.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This investigation was a cephalometric assessment of cranial base morphology and utilized cephalometric roentgenograms of a cross-sectional random sample of fifty Class I and fifty Class II malocclusions from the Loyola University Orthodontic Clinic in Chicago, Illinois. Five landmarks were selected and three angles and four lines constructed to the nearest degree of accuracy. The mean and standard deviation was calculated for each angle and linear measurement in each classification. The Student "t" test was employed to determine if a significant difference existed between the corresponding angular and linear measurements in each malocclusion.

Recognizing the various methods of studying dental and skeletal facial morphology, the necessity for knowing relationships in shape and variation are apparent. Evaluating these coordinated variations in shape for a group or population it is well to remember that the patient with malocclusion is an individual, to which "means" are applied only as guidelines.

The following assessment of the cranial base was made between the Class I and Class II malocclusion samples investigated, presenting some striking similarities.

1. The mean saddle angle was larger in Class II malocclusions than in Class I malocclusions, but not to any degree of significance.

2. The body tends to produce a constant relationship between the cranial bases and the gonial angle in Class I and Class II malocclusions. There is a tendency for the saddle and joint angles to balance their differences to achieve this aim.

3. The mean gonial angle was larger in Class I malocclusiion, as compared to Class II malocclusion, but not significantly.

4. The mean ramus height was greater in the Class I than in the Class II sample, but to no degree of significance.

5. The mean body length was not significantly

differnt in Class I malocclusions than in Class II malocclusions.

6. The means and standard deviations in this investigation closely approximate those of Bjork in his study of Swedish subjects, considering the variability of the age group studied.

It is therefore concluded that each individual is a unique dental and facial complex, and for an orthodontist to treat an individual he must know that individual by using all diagnostic means available.

BIBLIOGRAPHY

Bjork, Arne 1947 The Face in Profile. Sxensk Tandlakare-Tidskrift, Vol. 40, No 5B, suppl., Lund Berlingska Boktryckeriet.

__________ 1950 Some Biological Aspects of Prognathism and Occlusion of the Teeth. Angle Orthodontist; 21:3.

__________ 1955 Cranial Base Development. A.J.O.; March, 195-198.

__________ 1961 Relationship of the jaws to the cranium. Lundstrom's Ed., Introduction to Orthodontics, New York, McGraw Hill Book Co., pp. 104-140.

Blair, E.S. 1952 A Cephalometric Roentgenographic Appraisal of the Skeletal Morphology of Class I, Class II Div. 1, Class II, Div. 2 (Angle) Malocclusions. Master's thesis, University of Illinois.

Bolk, L. 1922 On the position, shifting, and inclination of foramen magnum in the skull of primates. Zeitschr., F. Morph. u. Anthrop., B. D. 17, s. 611.

Broadbent, B. H. 1931 A new X-Ray technique and its application to orthodontics. The Angle Orthodontist; 1:45-66.

__________ 1937 The face of the normal child. 7:209-233.

Braun, M. L. and W. G. Schmidt 1956 A Cephalometric Appraisal of the Curve of Spee in Class I and Class II

Division 1 Occlusions for Males and Females. A.J.O., 42:255-278.

Brodie, A. G. 1941 On the growth pattern of the human head from the third month to the eighth year of life. Am. J. Anat.: 68:208-262.

Brodie, Allen, Jr., 1952 A cephalometric study of the cranial facial morphology. Master's Thesis, University of Illinois.

Jarabak, J. R. 1967 Personal communication.

Lindegard, B. 1952 On the relationship between the upper alveolar process and the cranial base. Kungl. Fysiograt. Sallsk. Lund Forhndl., 22:1-10.

Reidel, R. A. 1948 A Cephalometric Roentgenographic Study of the Relation of the Maxilla and Associated Parts to the Cranial Base in Normal and Malocclusion of the Teeth. Master's Thesis, Northwestern University.

Ricketts, R. M. 1955 Facial and denture changes during orthodontic treatment as analyzed from the T.M. Joint, A.J.O., March, Vol. 41, No. 3, p. 163-179.

__________ 1960 The Influence of Orthodontic Treatment on Facial Growth and Development. The Angle Orthodontist. 30:p. 103-133.

Salzmann, J. A. 1966 Practice of Orthodontics. J. B. Lippincott Company, Philadelphia and Montreal.

Schudy, F. F. 1965 Vertical Growth Versus Anteriopposterior Growth as Related to Function and Treatment. The Angle Orthodontist. 34:p 75-93.

Subtelny, J. Daniel and Sakuda, Mamoru 1964 Open-bite; Diagnosis and Treatment. A.J.O., May, Vol. 50, No. 5, p. 337-358.

Wylie, W. L. 1959 Philosophy of Orthodontic Diagnosis. Am. J. Orthodont. 45:pp. 641-654.

APPENDIX

CLASS I DATA

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
1	M	11-4	116	156	119
2	M	14-8	117	142	132
3	F	13-6	125	147	129
4	M	13-0	132	150	117
5	M	13-4	127	140	124
6	F	10-0	123	153	127
7	F	14-0	128.5	137.5	134
8	M	14-5	130	147	129
9	F	14-6	124	153	135
10	F	11-6	124	142.5	127
11	F	13-0	135	133	130
12	F	13-6	118	151	130.5
13	F	13-4	123.5	151.5	119
14	F	10-6	130	141.5	129

CLASS I DATA

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
1	82	40.5	41.5	90.5	391
2	80	37	51	80	391
3	73	36	47.5	80.5	401
4	68	35	44	77.5	399
5	77	35	52.5	78	391
6	64	34	35	71.5	403
7	75	31.5	43	78	400
8	72	37	44.5	82.5	406
9	76	34	41.5	81	412
10	75	27	36.5	73.5	393.5
11	75	36.5	43	80.5	398
12	75.5	29.5	42	75	399.5
13	73	32	44	79	394
14	66	29	37	70	400.5

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
15	F	15-6	129.5	143	125
16	M	12-6	123	138	139.5
17	F	15-0	125	148	122
18	M	15-11	126.5	141	133.5
19	M	12-4	120	149	125
20	M	14-0	124	150	130
21	M	15-0	115	154	128
22	M	12-2	114	145	128.5
23	M	12-0	126	148	119
24	M	12-6	121	143	128.5
25	M	14-6	121	158	111.5
26	M	13-6	132	142.5	138
27	M	10-8	123	149	123
28	F	18-0	126	150	121
29	M	17-0	125	137	126
30	F	12-2	125	133	144
31	F	12-5	132	136	145
32	F	13-2	124	143	130

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
15	68	38	47	74	397.5
16	77	38	48.5	77	400.5
17	68	39	41	77	395
18	75	44	49.5	77.5	401
19	78	37	43	80.5	394
20	73.5	33.5	41	75.5	404
21	78	39	46.5	83	397
22	77	40	53	75	387.5
23	75	37	52.5	82	393
24	73	34	41	74	392.5
25	78	38.5	53	87.5	390.5
26	74	30	41	71	412.5
27	73	30	46	69	395
28	70.5	33	44	79	397
29	83	39	51	92	388
30	73	31	40	72	402
31	73	29	39	75	413
32	73	35	48	72	397

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
33	M	12-0	124	146	120
34	M	10-6	120	146	127
35	F	13-0	120	147	127
36	F	13-6	120	146	129
37	F	12-6	121	155	128
38	M	15-2	128	136	128
39	F	15-0	119	150	125
40	F	11-3	120	147	142
41	F	17-0	124	140	125
42	F	14-0	112	155	131
43	M	11-6	115	143	131
44	M	11-8	127	133	139
45	F	19-0	120	134	122
46	F	11-6	126	143	132
47	F	13-0	124	144	128
48	F	14-0	122	152	117
49	M	12-0	126	133	132
50	F	11-0	124	139	134

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
33	76	39	46	75	390
34	78	39	43	70	393
35	71	32	49	71	394
36	71	35	50	79	395
37	72	29	31	82	404
38	70	37	50	74	392
39	70	36	48	74	394
40	70	32	40	71	409
41	69	33	47	75	389
42	75	38	45	77	398
43	71	43	49	74	389
44	70	28	40	75	399
45	70	35	49	82	376
46	68	38	42	74	401
47	72	33	52	74	396
48	70	37	43	77	391
49	77	39	47	83	391
50	68	35	45	73	397

CLASS II, DIVISION I, DATA

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
1	70	33	45	68.5	391
2	72	36	42	76	392
3	70	38	47	80	394
4	74	37	42	76	398
5	74	33	40	74	402
6	71	38.5	53.5	82	391
7	69.5	31	38	68	398
8	71	33	41.5	72	399
9	73	29	47	69.5	392
10	76.5	42.5	51	87.5	391.5
11	74	32	46.5	82	391
12	74.5	37.5	46	74	400.5
13	73.5	35	43	77.5	399.5
14	73	33	50	70	393
15	77	34	36	70	400
16	74.5	31.5	40.5	73.5	402

CLASS II, DIVISION I, DATA

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
1	F	12-4	128	140	123
2	M	12-0	127.5	132.5	132
3	F	12-9	121	156	117
4	F	13-1	129	133	136
5	F	10-11	122	145	135
6	M	14-2	125	140	126
7	F	10-1	123.5	149	125.5
8	F	13-2	134	143	122
9	M	11-0	127	142	123
10	M	13-3	115	153.5	123
11	F	13-8	132	143	116
12	F	14-0	135	139	126.5
13	M	12-0	129	149.5	121
14	M	13.0	135	130	128
15	M	10-11	126.5	142	131.5
16	F	14-1	122	145	135

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
17	75	38	46	74	388
18	75.5	39.5	44.5	68	411
19	70	35	41.5	67	399
20	70	37	43	77	390
21	78	35	42	78	397
22	72.5	33	33	69.5	403
23	80	39.5	48.5	81	390
24	79	34	40	76	399
25	71	37	42	75	390
26	75	38	50	84	391
27	79	39	43	82	396
28	78	37	42	73	394
29	74	32	39	75	403
30	78	34	36	84	401
31	76	35	43	83	402
32	78	44	51.5	85	389
33	66	36	42	72	397
34	73	28	46	76	395

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
17	F	12-8	122	142	124
18	M	14-0	119	162	130
19	F	12-10	121.5	138.5	139
20	F	12-0	127	146	117
21	M	14-6	120	148.5	128.5
22	M	12-6	133	136	134
23	F	15-7	118	149	123
24	F	13-6	121	145	133
25	F	12-0	127	137	127
26	M	15-6	131	137	123
27	M	13-3	125	141	130
28	M	13-1	120	146	128
29	M	10-9	127	142	134
30	M	14-8	124	149	128
31	F	12-5	127	146	129
32	F	14-7	128	138	123
33	F	10-4	128	143	126
34	F	12-9	123	148	124

Patient Number	Anterior Cranial Base (mm)	Posterior Cranial Base (mm)	Ramus Height (mm)	Body Length (mm)	Sum Angle (degrees)
35	78	35	40	74	400
36	77	29	39	78	405
37	66	34	42	67	391
38	75	45	47	86	386
39	75	36	50	76	399
40	73	29	42	68	395
41	79	33	42	77	396
42	72	32	42	66	388
43	74	38	40	75	394
44	70	34	37	75	396
45	76	38	45	70	388
46	78	35	41	79	392
47	70	33	44	75	399
48	72	38	42	77	401
49	65	35	43	70	400
50	72	30	38	72	403

Patient Number	Sex	Age Yrs Mo	Saddle Angle (degrees)	Articular Angle (degrees)	Gonial Angle (degrees)
35	M	11-2	115	145	140
36	F	13-9	128	147	130
37	F	10-10	133	125	133
38	M	13-0	125	144	117
39	M	13-5	142	125	127
40	F	11-3	120	142	133
41	M	12-9	124	149	123
42	F	11-4	120	136	132
43	F	11-3	121	149	124
44	F	12-0	123	141	132
45	M	12-5	127	136	125
46	M	12-0	118	149	125
47	M	14-3	121	143	135
48	F	11-0	125	151	125
49	F	10-8	114	153	133
50	F	10-6	129	137	137

APPROVAL SHEET

The thesis submitted by Laurence I. Carlsen, Jr. has been read and approved by members of the Department of Oral Biology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

May 10, 1968
DATE

Donald C. Hilgers
Signature of Advisor