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A Roentgeno Cephalometric Study of Seventeen-Year Old Japanese Using Several Analyses

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A ROENTGENO CEPHALOMETRIC STUDY

OF

SEVENTEEN-YEAR OLD JAPANESE

USING SEVERAL ANALYSES

by

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DEDICATION

To my parents, Jiro and Kiye Mitani,

with my appreciation and my love.

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VITA

Seiji Mitani was born in January, 1950 as the second son of Jiro and Kie Mitani in Osaka Japan.

In 1968 he graduated Kobe High School in Hyogo, Japan. He received Shigakushi (Doctor of Dental Surgery) from Osaka Dental College in March 1975. In May 1975, he passed the National Board of Dentistry in Japan and became a licensed dentist. Also in May, 1975 he started his orthodontic and teaching career as an assistant professor of the Orthodontic Department of the Matsumoto Dental College in Nagano, Japan at the undergraduate level. In January, 1977 he came to the United States of America to study English and Orthodontics. The first six months, from January, 1977 to June, 1977 he studied English at the English Language Institute, University of Michigan in Ann Arbor, Michigan. In July 1977, he enrolled at the Graduate School of Orthodontics and in post graduate program in oral biology at Loyola University School of Dentistry in Chicago. In May, 1979 he received the certificate of specialty in the orthodontics from Loyola University.

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CHAPTER I

INTRODUCTION

Since Broadbent[1] introduced the technique of the standard oriented roentgeno-cephalogram in 1931, this method has been used to study the cranio-facial morphology and the growth and development of the cranio-facial complex. This method also was used for diagnosis in clinical orthodontics.

For the clinical application of this method, many studies had been reported to make the analysis more useful and understandable.

For example: Björk[2] published his standard oriented roentgeno cephalometric study of Swedish children and his analysis for the standard oriented roentgeno cephalogram. Downs[3] presented his analysis with Frankfort Horizontal as a reference line and determined the Caucasian norms. Graber[4] reintroduced anterior cranial base (Sella-Nasion Plane) as a reference plane for the position of maxilla and mandible in the Northwestern analysis. Steiner,[5] Tweed,[6] Jarabak,[7] Ricketts,[8,9,10,11] Coben,[12] and Wylie,[13] each introduced his own analysis using standard oriented roentgeno-cephalogram and attempted to determine Caucasian norms.

These studies of oriented roentgeno-cephalograms have been done not only for Caucasians, but also other races, and ethnic groups. In 1948, Downs introduced his analysis; Takano[14] studied American Japanese; Kayukawa,[15] Iizuka and Ishikawa[16] studied the Japanese; Chan[17] studied the Chinese; Altemis[18] studied the American Negroes; Garcia[19] studied Mexican Americans, and these people tried to determine the norms for these races and ethnic groups. Most of these pioneer studies were done in Europe and the United States of America, however, the Caucasian norms and standards were more complete than those of any other races.

The morphology of the cranio-facial complex, is affected by individual genetics, age, sex, race, etc. Because of the racial difference, clinically, Japanese can not directly apply the Caucasian norms to the Japanese patient. That means Japanese are not able to use the old basic studies or new clinical studies of Caucasians. The Caucasian studies have to be extrapolated for Japanese use, and these norms must be corrected for application to Japanese facial patterns.

Several Japanese studies had been done by using oriented roentgeno-cephalograms but those studies only dealt with the relationship of the maxilla and mandible referring to the anterior cranio base or Frankfort Horizontal and they did not deal with the complete structure of the cranial base and mandible because of the limitation of the analysis. Some researchers tried to find the difference between the norms of Caucasian and the norms of Japanese but they could not clearly demonstrate the differences because of the limitations of the analysis. Those analyses could not show the pattern of the cranial base and characteristics of the mandible in any detail.

The purpose of this study is as follows:

1) To study the skeletal pattern of the Japanese by using roentgeno-cephalograms and to determine the normal variation.
2) To compare Japanese males and Japanese females to determine the sex difference in denture and skeletal pattern.
3) To determine the racial difference between Caucasians (of previous studies) VS. Japanese (of this study).
4) To relate previous Japanese studies VS. the results of this study.

CHAPTER II

REVIEW OF LITERATURE

A. AMERICAN STUDIES

In 1931, Broadbent[1] introduced a new method for the roentgeno-cephalometrics and its application to orthodontics. In this article, Broadbent discussed the mechanics of the standard oriented roentgen machine, the craniostat, the anode, the enlargement of image, etc. He also explained the way he collected the samples and the way he made tracings. In summary, he especially stressed the importance of the standardized roentgenographic technique. It can make accurate determinations of changes in the living head that may be due to developmental growth or orthodontic treatment. By this article, Broadbent introduced the usefulness of the roentgeno cephalometrics for scientific solution of the orthodontic problems, the study of growth and development, record of treatment, etc.

In 1937, Broadbent[20] published "The Face of the Normal Child". In this study, Broadbent discussed the patterns of growth and development of the normal child face. For the comparison of the different age groups, stable points were needed. Broadbent introduced point R, (that distance midway on the perpendicular from the Bolton-nasion plane to sella turcica), as the registration point for registering tracings of subsequent pictures of the same individual and of different individuals as well. Broadbent not only showed the growth pattern of the face, but also determined the development of the dental pattern. He showed the profile dental patterns in relation to the supporting structures in each developing stage. He stated, that there was no correlation between the patterns in mandibular development and the developing permmanent molars. Even Broadbent stated that he followed the Bolton standard of time of beginning of classification. Broadbent also discussed the change of the dentition in frontal x-ray films and explained the movements of incisors and canines during the so called "Ugly Duckling" stage. Broadbent stated; "A detailed study of those changes in the relations of the teeth during developmental growth presents patterns that are so unlike those in the adult normal that they are very easily mistaken for abnormalities. Since the crowns of the permanent teeth reach their adult size before they erupt, they appear on eruption to be too big for the juvenile mouth. The shedding of the deciduous incisors and the eruption of their successors mark the advent of the striking "Ugly Duckling" stage of occlusal development.

In 1939, Krogman[21] tried to see the face in three dimensions and gave the methods of measurement. Krogman appreciated the development of the cephalogram. Krogman stated, "With the introduction of the x-ray, we witness a merging of two major techniques: the purely craniometric, based on the skull alone; and the purely cephalometric or gnathostatic, based on the head and soft tissue alone. Each has its limitations, but each surrenders its best to the x-ray. We are able, finally, to correlate the earlier craniometric and the later cephalometric into the all inclusive roentgenographic". Krogman also discussed growth rates of upper and lower facial height and breadth and length (depth). In summary, Krogman stated, "1) The techniques of facial growth study are soundly based on craniometric, x-ray and maturational methods. 2) Growth in the face is in three planes: height, breadth, length. 3) Incremental growth is rhythmic, with an interplay between the several components, each with its own rate of growth. 4) Differential length growth in upper and lower face leads to malocclusion. 5) Face growth is susceptible to the same growth impulses or retardations as is body growth. 6) The concept of the normal is best understood in terms of a predictable statistical variability".

In 1941, Broadbent[22] discussed the changes of the dentition from one month after birth to the adulthood. He said, "The x-ray is to gross anatomy what the microscope is to histology; it reveals differentiation of parts and structural and morphological changes can be followed in detail". "The study of the eruption of teeth based on the measurements of skulls of dead children of different ages with unknown health records supplies fragmentary information, while standardized roentgenograms are a comprehensive record of the status and progress of developmental health in the same and different individuals".

In this article, Broadbent also discussed the general growth pattern of the face superimposing point R and paralleling the Bolton-nasion plane. He stated, "We find those landmarks in the median sagittal plane moving in a straight line forward and downward with the exception of nasion (NA) that is above the fixed point R. This moves forward and slightly upward. The anterior end of the palate, the incisor teeth and gnathion (GN) move downward and forward to a greater or lessor degree depending upon their proximity to the cranial base. The other landmarks shown, with the exception of the posterior end of the palate, migrate downward, forward and laterally.

In 1946, Brodie[23] explained the basis of the statistics and the norm concept, to clarify his point of view, and his trial abandonment of the norm concept in favor of more individualized treatment standards. Brodie presented several cases to back up his point and discussed growth patterns of face, including malocclusion patterns. He stated, "At the present time, we are in great need of two types of information. One of these is the path of development being followed by any given case. The other is the matter of rate of growth so that the full potential of an individual may be predicted. At present, no method seems to offer better promise than does serial roentgenology, but the term serial must be stressed". From his point, the comparison with two x-ray films that were made with a considerable time interval between is better than the comparison with norms.

Brodie summarized his points as follows: 1) The human face is a complex collection of parts composed of a number of bones and serving jointly a number of functions. 2) These bones and the areas to which they contribute, show wide ranges of variability in the matters of rate and time of growth, sequence and size attainment. 3) The variants are not always in the same direction; indeed, they may be quite opposite. Any combination seems to be possible. 4) The growth of the pattern is proportional. This means that if the disharmony is present from before birth; it becomes neither better nor worse. It cannot be changed by treatment. 5) The teeth and alveolar processes constitute the only area of the face where changes may be expected or induced. 6) Eruption order and time vary greatly in different individuals, and this introduces possibilities not present in a grouping of bones. Precocious eruption in jaws growing at an average rate, or average eruption in jaws growing at a slow rate introduce temporary disharmonies that are frequently not self-correcting. The tongue, lips, and cheek constitute the major environmental factors of the alveolar processes and teeth. Their harmony in growth, size and tensions with the teeth and processes are necessary for stability".

Brodie concluded this article; "In conclusion, this paper presents a plea for the abandonment of the norm concept. This does not mean that all statistical methods are to be discarded. We must study growth increments and employ mathematics to plot their gradients".

In 1946, Tweed[6] introduced the Tweed triangle that was formed by Frankfort horizontal plane, mandibular plane and long axis of mandibular central incisors. Tweed tried to determine the growth pattern and prognosis from the range of the Frankfort-mandibular plane angle. He summarized: 1) In cases that fall within the Frankfort-mandibular plane angle range of sixteen degrees to twenty-eight degrees, the prognosis varies from excellent for those nearest the sixteen degrees extreme to good for those cases nearest the twenty-eight degrees extreme. 2) In cases that fall within the Frankfort-mandibular plane angle range of twenty-eight degrees to thirty-two degrees, the prognosis will vary from good at twenty-eight degrees to fair at the thirty-two degrees extreme. 3) In cases that fall within the Frankfort-mandibular plane angle range of thirty-two degrees to thirty-five degrees, the prognosis is fair at thirty-two degrees and not favorable at thirty-five degrees. 4) In cases that fall within the Frankfort-mandibular plane angle range of thirty-five degrees upward, prognosis is not favorable at thirty-five degrees and virtually nil at extremes such as forty-five degrees to fifty-five degrees.

In 1947, Wylie[13] used the Frankfort horizontal as a reference line and he projected several landmarks to the Frankfort horizontal. Wylie tried to show the skeletal relation by measuring the distances to the landmarks. Wylie stated, "We may say that each of the following factors, when greater than average in size, predispose toward a Class II relationship: the length of the cranial base between the glenoid fossa of the temporal bone and the tuberosity of the maxilla, the overall length of the maxilla and the position of the maxillary first permanent molar as measured forward from the tuberostiy of the maxilla. The only other factor involving absolute size which is to be considered is the overall length of the mandible, which of course predisposes to the Class II relationship when it is undersized". Wylie presented the mean values for males and females of samples of Class I cases with a mean age of eleven years, five months.

In 1947, Margolis[24] published the first part of his three part article, "A Basic Facial Pattern and Its Application in Clinical Orthodontics".

In this first article, Margolis used thirty Indian skulls from the Peabody Museum to make a pilot study of the maxillofacial triangle that was constructed by the cranial base line (nasion and the top of the occipitosphenoidal suture), the facial line (nasion and a tangent to the mental eminence) and mandibular line (the tangent to the inferior border of the mandible).

Margolis stated; "The results were sufficiently interesting and indicative of a pattern to warrant similar treatment on white American children. One hundred children between age six and nineteen years were then selected on the same basis. No separations were made because of national origin, age or sex. Later it was observed that separation according to age, sex or national origin had no effect on the statistical values of the observations".

Margolis reported the mean value of the three angles of the triangle and some observations.

In 1947, Björk[2] described the faces of three groups of people. Group I contained twenty twelve year old males, group II contained 322 boys who had passed the age of twelve, but not thirteen with very good dentitions (not more than a single permanent tooth decayed, nor more than a single tooth missing, and no orthodontic treatment). Group III contained 281 conscripts, who had passed the age of twenty-one but not older than twenty-three.

Björk presented his analysis and reported the means of the measurements. He used S-N plane as a reference plane and he determined the facial pattern by using his facial diagram that shows the relationship between the cranial base and the profile. Björk discussed the nature of prognathism by using his facial diagram and changed the lines of the facial diagrams to show the causes of prognathism.

Downs[3] introduced his analysis and norms for Caucasians in 1948. In this paper, Downs determined the range of facial and dental patterns within which one might expect to find the normal. Downs used twenty living individuals with excellent occlusion, ranging in age from twelve to seventeen years, about equally divided as to sex. He discussed the reference planes (Frankfort horizontal, S-N plane and Bolton plane) and suggested the use of Frankfort horizontal because the facial angle formed between Frankfort horizontal and the facial plane had closer relationship to facial types than any other reference plane. Downs introduced in his analysis five skeletal related measurements and five dental related measurements. He presented four individual cases (Class I, Class II, Class III and Class III surgery) for discussion of clinical application. The Downs analysis is the result of three years experience with the method in practice and in the Orthodontic Department of the University of Illinois, University of California, Northwestern University and University of Indiana.

In 1951, Baum[26] reported a study in which he used sixty-two children of the Seattle public schools equally divided as to sex. The subjects had clinically excellent occlusions, considering tooth relationships only. The mean age of the male subjects was twelve years, eight and one-half months and the female subjects was twelve years, seven and one-half months. All of the subjects were Caucasian. Baum used the same landmarks and measurements as Downs. Baum also used some of the measurements introduced by Riedel.

Baum compared his results with Downs norms and found some differences, but he thought that was due to the different age groups as he stated in his discussion, "These differences are shown by the significant values obtained when the "t" test was applied in comparing the combined male and female groups to Downs' group."

"It is important, therefore, that we appreciate the difference in skeletal and denture patterns of children and those of adults. The child must be compared to a normal range compiled for his own age group and not to one of an adult or older group".

In summary and conclusion, Baum stated : 1) It was shown that in this age group, the male had a more convex face than the females (greater angle of convexity). 2) It was also shown that compared to an older age group, the group studied in this work had a more convex face, less upright incisors measured from either occlusal plane or mandibular plane and a more protrusive denture measured from the incisal edge of the upper incisor to the A-Po plane.

Baum thought the big differences between his norms and Downs norms were because of the age difference but Baum used an average age of twelve years, seven months, Downs used an average age of fourteen years old. The two years age difference should not have a significant influence.

In 1951, Thurow[27] brought out several problems that happened when people applied the cephalogram in their practice or research. He discussed the problems which could make x-ray film image not acceptable for reading. Thurow especially paid attention to the problem of enlargement that was made when different distances between the subject to the film surface was used. For example, the head of a human is not flat, it has thickness. The difference between left molar and right molar can make a visable difference. He also discussed the size of the x-ray target (source of the rays).

In this study, he evaluated the enlargement and he stated in the summary, "Where do we go? Cephalometrics was developed for just one thing: accurate measurements. And these accurate measurements are of value only if we make comparisons between them. So let's compare; let's check up on our diagnostic guesswork and what really happens: Some of the answers can be downright startling. Let's start getting the picture before we plan to start treatment; then later diagnosis will involve a little less guesswork". Thurow also lists the cephalometric requirements in either case.

1. Orient and adjust the equipment carefully.
2. Position the patient carefully.
3. Record the subject - film distance (in millimeters) if a constant film position is not used.
4. Record the patient name, age, and the date.

In 1951, Wylie[28] discussed two unpublished reports and one masters' thesis. Cotton and Wong from the University of California and Takano from the University of Washington did studies of Downs analysis applied to other races, American Negroes, Nisei (American Japanese) and American-Chinese. Cotton used twenty San Francisco Bay area Negro individuals, ten males and ten females ranging in age from eleven to thirty-four years. Cotton was careful to point out that his sample did not in every instance represent perfect occlusal relationships. Takano had twenty Seattle Nisei (American born Japanese), evenly divided as to sex with a mean age of twenty-one. Takano's description of the material coincides with that given by Downs: clinically excellent occlusions with good facial balance. Wong's group consisted of twenty American born Chinese from San Francisco's Chinatown, ten males and ten females ranging in age from eleven to sixteen years. In the examination of 600 Chinese children, Wong could not find "normal" as Wong had come to apply the term to Caucasians, but Wong chose as subjects only those having "normal arch relationship and good facial pattern".

Wylie stated, "Only Takano subjected the data to the usual tests for significant differences between corresponding means for whites. He found that in the Nisei skeletal pattern, only the angle of convexity and the Y axis differed in mean value from that of the white by significant amounts: on the other hand, four out of five denture pattern values (cant of occlusal plane being the one exception) differed significantly from the white means. Takano states: "The greater Y axis angle in the Nisei groups may indicate a shorter anteroposterior length of the face, or that growth is predominantly in a downward direction rather than a forward direction, which would substantiate previous statements made by physical anthropologists. The greatest difference lie in the denture pattern - significantly more protrusive in the Nisei group than in the Caucasian group".

In 1951, Krogman[29] discussed a historical survey of the many planes which have been devised or adapted to elucidate type-similarities and type-differences in direct comparison. He classified the various methods logically into four main groups: I) Resting Horizontal Planes.

II) Planes Using Various Craniometric Points. III) Planes Centering Upon the External Auditory Meatus. IV) Roentgenographic Cephalometric Planes. Krogman presented the definition and the principle of each plane for the determination of the reader.

He stated in his discussion, "The physical anthropologist, in using his cranio metric measurements, descriptions, planes, and so on, learned that no single dimension, no single index, no single morphologic trait could stand for the whole. The type is a complex whole, the sum of all parts. Similarity is urged upon the cephalometrician that no one dimension, no one angle, can assume a type-difference that is of absolute diagnostic value.

Roentgenographic cephalometry is the natural inheritor of craniometry, and it has gone far ahead, as it should. It is three-dimensional; it penetrates into the very depths of growth; and it truly is time-linked in the sense that it is an auto-repetitive technique. As a research tool in the growth of head and face is, it has no peer. We urge that its interpretation have the conservatism consistent with the inherent limitations of growth-movement. The essence, therefore, of the roentgenographic cephalometric method is its ability to capture moments of growth and then, on a serial basis, to link them meaningfully in terms of individual growth progress.

In 1952, Downs[30] discussed five different patterns of disharmony of the face and determined the relationship of facial types and evaluate the static analysis. He also presented three cases and discussed the annual change of the individual person. Downs thought a study of the form of the head presents a four dimentional problem. Therefore he divided the analysis into two parts, static and dynamic.

In summary, he stated, "The profile pattern had commanded the most attention, probably because it affects the appearance of an individual so much and was of major concern in orthodontic therapy. The cephalometric roentgenograph had provided a means of accurately appraising the relationships of the parts of the face leading to a description of the mean or average facial form of normal occlusion. This method of study and description of the skeletal and denture patterns of an individual at any particular time has been described as a Static Analysis".

When comparison are made of records taken of the same individual at different times, the result is a quantitative interpretation of changes and may be called a Dynamic Analysis.

It is not presumed that cephalometrics will supplant other methods of analysis; rather it should be looked upon as an aid in understanding the others.

In 1952, Riedel[31] published his study of the cephalometrics about the maxillo-cranial relations. In this study, Riedel used fifty-two adults with excellent occlusions, ages eighteen to thirty-six; twenty-four children ages seven to eleven, possessing excellent occlusions; thirty-eight individuals with Class II, division I malocclusions, ten with Class II division 2 and nine with Class III malocclusions. He did not make any attempt to evaluate these groups based on sex. Riedel used the S-N plane as a reference plane. He also used the angles, S-N-A and S-N-B to determine the relative anteroposterior position of the maxilla and the mandible. He made comparison using adults, VS. children, and normal occlusion group, VS. malocclusion groups. His finding are as follows: 1) Using S-N-A and others of a similar nature, no significant difference could be found in the anteroposterior 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, when the younger age group was compared with adults. 2) The anteroposterior relation of the mandible to the cranial base was found to be significantly different in patients exhibiting excellent occlusion when they were compared with individuals possessing malocclusion. 3) In normal occlusion A-N-B was approximately 2 degrees and in malocclusions to vary considerably.

In 1952, Wylie[31] and Johnson discussed Wylie's article (1947). They discussed many suggestions and the reasons why they could accept or reject them. They also determined the vertical components using later head plates.

They used 171 head plates taken prior to orthodontic treatment in an age group of eleven to thirteen years were segregated into fifty-seven "good", sixty-one "fair" and fifty-three "poor" facial patterns, using subjective appraisal only. On each film measurements of facial height at the profile, length of the mandibular body and the mandibular ramus were made by them. They also measured gonial angle, vertical placement of the glenoid fossa of the temporal bone.

Wylie and Johnson compared "good" and "poor" facial patterns. In summary, they stated, "Orthodontists often speak of "good" and "poor" facial patterns, usually without defining the distinction in quantitative terms, although the Frankfort-mandibular plane angle and other angles are coming into increasing use in this connection. Because angles serve poorly to localize and differentiate, this study is directed at showing specifically how certain anatomical areas vary when esthetic distinctions are drawn".

Wylie and Johnson listed the conditions that made the subjective evaluation tending towards "poor": 1) lower face height becomes large, 2) the angle of the mandible becomes large, 3) placement of the glenoid fossa of the temporal bone is relatively high.

In 1952, Graber[4] discussed the terminology of cephalometrics and clinical application of the cephalogram. He defined the landmarks, presented the norms and explained the meaning of each measurement of the analysis. Graber tried to correlate the numbers to the facial types and Angle's classification.

Graber also described a method of taking cephalogram in the clinic that used ordinary x-ray machines and smaller film-holding cassettes with short distance of target-film distance. By this way, Graber thought the cost and x-ray exposure would be cut and the peripheral magnification could be reduced.

In summary, Graber stated, "Cephalometrics is not a panacea for all our troubles. There is no substitute for clinical experience and judgement, but cephalometrics will help a great deal. It offers valuable assistance in growth and development appraisal, in picking up abnormalities, in studying facial type, and in arriving at a functional analysis.

In 1953, Brodie[33] published his study of nineteen Caucasian males, age range of eight to seventeen years. This sample came from the Bolton study at Case Western Reserve University.

His findings were as follows: 1) There is a strong tendency for the nasal floor to remain stable throughout the growth range. In those cases that do not exhibit change it increases its angular relation with the anterior cranial base. 2) The junction between the pterigoid process and the tuberosity of the maxilla, namely Ptm, is the most stable point in the facial area, at least in an anteroposterior direction. 3) The occlusal plane is stable in about one half the cases but its behavior in the others leads to a decrease in the angle between it and the N-S plane. 4) The mandibular border, similarly show no appreciable change in over half the cases. In those cases where it does change it almost invariably shows a behavior similar to that of the occlusal plane, that is, a tendency to become more parallel with the anterior cranial base. 5) The angle N-S-Gn, which relates the Y axis of growth and the anterior cranial base, has again been shown to be quite stable. 6) The late stage of growth has been showed to be accompanied by a continuation of forward and downward movement of the anterior nasal spine and of pogonion while the dental arch and its supporting bone tends to move more slowly and thus drop behind.

In 1953, Donovan[34] used cephalometric radiographs taken with the mandible at rest position and with the teeth in occlusion on eighty-seven individuals possessing malocclusion. He took radiographs before, during and subsequent to orthodontic correction of the malocclusion and he took at least three sets of radiographs or more for each individual. Donovan discussed the change of S-N-A, S-N-B and the difference of A-N-B from the view point of growth and of treatment. In the discussion, he stated, "As indicated by the examples presented, there was much variation in dental malocclusion, apical base disharmony, treatment plans, treatment results and facial growth trends. The great majority of the successfully treated cases showed favorable growth trends and the failures presented either extreme apical base disharmony or unfavorable growth trend". Donovan discussed the change of S-N-A and S-N-B and he tried to show the cause of the change and the results of the change.

Donovan concluded as follows: 1) The quality of orthodontic results, time required for treament, and reaction to mechanical therapy are influenced by the following: a) The anteroposterior relation of the mandible to the maxilla. b) The increments of facial growth during orthodontic treatment. c) The direction of growth of facial structures (maxilla and mandible) during orthodontic treatment. 2) It is possible by means of cephalometric radiography to accurately appraise the anteroposterior relation of the mandible to the maxilla. 3) the growth trends of facial structures can be appraised only generally by cephalometric radiography before orthodontic treatment. 4) At the present time, increments, detailed direction, and the time of growth cannot be anticipated in individual cases before orthodontic treatment.

Margolis[25] published the second part of his article "A Basic Facial Pattern and its Application in Clinic", in 1953. In this study, Margolis reviewed the maxillofacial triangle and presented the mean, the standard deviation and the standard error for three angles as a result of studying 181 Caucasian American children between the age of six and nineteen years selected by observation because of balance and harmony of facial development. Margolis also studied other races and he stated, "Preliminary observations suggest that there is a significant similarity of the maxillo-facial triangles in all races of modern man, when the facial skeletons are well developed in balance and harmony. To confirm this observation, measurements on races other than caucasian, statistical treatment is being applied to other ethnic groups". Margolis' also discussed the relationship between the variance and harmony of the face and a maxillo-facial triangle of the several facial types.

After a discussion of facial pattern and malocclusion, Margolis stated, "Further occlusion of the teeth is influenced not only by the development of the craniofacial skeleton, but also by the excursions of the mandible in function, resulting from neuromuscular activity".

Margolis also stated, "It becomes increasingly evident that analysis of a dentofacial deformity requires:

1. A survey of the craniofacial skeleton.

2. Orientation of the dentition of this bone frame.
3. A detailed study of occlusion.
4. Integration of valid and pertinent data obtained from 1, 2, and 3.

In 1953, Steiner[5] showed the Frankfort plane was not accurate because of the difficulty in positioning of the ear posts. He suggested the use of S-N plane instead of the Frankfort plane and also presented his analysis and ideals with standards for orthodontic treatment. Steiner discussed his cases by using his analysis but he did not explain where his norms came from and how he established his analysis. From the numbers of his norms, the data possibly came from a study by Riedel (1952)[30] and some other Northestern University studies.

In 1954, Graber, T.M.[35] discussed the analyses and the reports of clinical change. Graber stated, "There is no doubt that the initial use of cephalometric radiographs as diagnostic criteria had an institutional character. Cephalometrics was rightly a research tool". After reviewing articles, Graber stated, "In this all-too brief survey of cephalometric criteria, there is one strong continuous thread - the attempt to construct a norm or standard. The need for such a standard on which to base our case analyses and therapeutic goals cannot be challenged. The actual creation of this norm concept has been most difficult, fraught with the pitfalls of mathematic expression of morphologic and physiologic variance. Attempts to reduce anatomic and functional relations to angles and numbers, changing a three-dimensional phenomenon into a two dimension linear diagram, have led some of us astray. Studies at Northwestern University has shown us the broad range of combination of cranial and facial components. To accept a mean as an absolute treatment goal is to ignore a majority of populace. To arbitrarily select one or two convenient measurements as prognostic or therapeutic clues is to overlook the interdependance of multiple individual characteristics, which are unrecognizable in cross-sectional grouping of so-called normals. Our goal must be, then, an individualized norm, using group standards only as a guide".

Graber predicted the future roles of cephalometrics and showed people the way to apply cephalometrics.

In 1955, Ricketts[8] studied facial and denture changes by using cephalograms and cephalometric laminography. The purpose of his article was: 1) to describe the mechanism of growth of the mandible and its relation to changes in the face; 2) to show how identical treatment procedures will induce a variety of results in patients expressing different growth tendencies; and 3) to indicate how treatment should be geared to the manner of development of the face.

Ricketts found there was not much difference in the shape of the condyle between Class I samples and Class II samples but Class III samples showed a difference, long and narrow condyles seated upward and forward in shallow fossae. Ricketts discussed the functional differences of three different types of malocclusion, treatment change of the condyle, the growth change of the condyle and rest position, by using the cephalometric laminography.

Ricketts also reported growth changes in the cranial base, changes of mandibular position and tooth positions by treatment and growth. Ricketts tried to connect the knowledge of growth to treatment. He stated, "In order to take advantage of growth, we must have some idea first, of its amount, and second, of its direction. We should think in terms of growth on the Y axis and plus or minus changes in the Y axis in evaluating facial change". --- "Probably the most important aspect of growth is its relationships to anchorage in the lower arch. Patients with high mandibular plane angles and changes were evident on the Y axis".

Ricketts stressed the importance of knowledge concerning tempormandibular joint behavior and he tried to show that within the temporomandibular complex lies the key to knowledge of growth and physiologic changes in the face during treatment.

In 1955, Coben[12] reported a study involving fourty-seven Caucasians, composed of twenty-five males and twenty-two females, none of whom received orthodontic treatment. Two lateral cephalogram were taken of each subject; the first representative of the age period, eight years ± one year; the second, the age period, sixteen years ± one year. These forty-two persons exhibited excellent occlusions or Class I malocclusion. Coben used Frankfort horizontal as the reference plane. He projected several landmarks on the Frankfort horizontal and measured the distances between the landmarks as the depth. He then measured the distance perpendicular to the Frankfort horizontal as the height.

In discussion, Coben stated; "From a study of human facial form and growth, one cannot help but be impressed with the infinite variation in the size, form, and growth of all structures. To comprehend variation of facial types and differences in the growth behavior of faces, it is not sufficient to study any single variant alone, for the significance of each characteristic lies in its integration in the total facial morphology. Variation has been shown repeatedly in the morphology and growth of the mandible and maxilla, but little has been said of the role of the cranial base from the dentofacial complex, in reality there is no such division. The importance of the cranial base in facial growth also has not received sufficient attention. The superimposed tracings on basion, with Sella-Nasion planes parallel, graphically illustrate the mechanism by which growth of the cranial base carries the upper face forward and upward away from the vertebrae column, leaving the mandible behind. Difference appear to exist not only in the absolute increment of the posterior cranial base, but also in its directional growth, contributing more to facial depth in one person and more to height in another".

In 1956, Holdaway[36] studied the question using more than seventy-five cases to show the change that occured during treatment. The question he asked was, "How much effect can orthodontic treatment have in bringing about relationships of these skeletal landmarks, commonly referred to as point A and point B?" He used A-N-B angle as a special reference of the maxillo-mandibular relationship and determined the changes of the maxillo-mandibular relationship by orthodontic treatment. Holdaway also asked another question, "Which case cannot be treated to the favorable zero to four degrees A-N-B range?" and he answered as follows: 1) Nearly all girls thirteen years of age or over and boys past sixteen years of age, 2) children younger than this who obviously have had a growth and maturation rate earlier than normal, 3) A-N-B angles greater than nine degrees, regardless of type of mandible, 4) S-N-Go-Gn plane angles is excess of forty degrees, where associated with A-N-B angles greater than five degrees.

In summary, he observed: "---3) Treatment objectives should aim at reducing high A-N-B angles to as near zero to two degrees as possible. 4) Good facial harmony is found in both prognathic and orthognathic persons so long as the apical base orientation does not exceed a range permitting compensational dental adjustments. 5) Patients treated during periods of active growth respond with better apical base changes than do patients treated during non-growth periods."

Good reductions in the A-N-B angle have taken place in nearly all cases having higher than four degrees A-N-B angle in which active growth occurred.

In 1956, Hixon[37] discussed two topics: 1) uses and limitations of norms and 2) evaluations of normative data for diagnosis and treatment planning. In the first part, "Some Uses and Limitations of Norms", Hixon explained the statistical meaning of "the average" and "the ranges" and characteristics of groups. He also discussed errors of measurement.

In the second part, "Evaluation of Normative Data", Hixon presented results of research in facial growth at Iowa State University showing, the change of twenty-seven North-European Caucasian girls measured at five and thirteen years of age.

In the summary, Hixon stated, "1) Most available cephalometric norms describe faciodental traits with reference to the variability of the trait in a population. 2) Clinical use of the norms is thus appropriate for describing or ranking the patient in terms of the norm. It is abusing the norm to use it alone for evaluation in diagnosis, or to use the average as an objective in treatment planning. A norm is not a substitute for professional judgement. 3) A norm is not a single value, but a range of values. Thus, norms constructed in terms of percentiles, such as the ones used in height and weight norms, have certain advantages. They are easy to understand. 4) Until we can construct a larger body of knowledge, our normative use of present cephalometric data should recognize such limitations.

Sample sizes of most studies are too small to represent fully the variability of a population. Also, the samples have usually been subjectively selected; for example, on the bases of normal occlusion".

In conclusion, "----- the question becomes: 'Do cephalometric data of the normative type have a role in orthodontics today?' In spite of the limitations outlined, I believe so. --- The yardsticks may be a bit elastic at present, but they are far better than no yardsticks. Within another decade, our cephalometrics and normative data should be even more complete and take into account age, sex and possibly racial differences, as well as providing a better understanding of individual patterns of growth".

In 1957, Ricketts[9] published, a follow-up study of his article in 1955. In this two part article, Ricketts presented cephalometric procedures and findings, culminating in the application of a single head film for the estimation of growth and treatment changes in first part.

In the second part, Ricketts discussed the esthetic considerations in the treatment planning. Ricketts introduced the "esthetic plane" for the reference of lip balance and facial harmony. He also reported the determination of the tooth relationship consistent with cases exemplifying ideal lip balance and facial harmony as follows". Great significance was placed on the point A-pogonion plane as a reference line. The lower incisor was related in angulation and anteroposterior position to this plane. --- The ideal position was held to be a lower incisor related at twenty-two to twenty-three degrees and zero to one mm. anterior to the A-Po plane".

In 1958, Graber, T.M.[38] reported on the cephalometric workshop that was held under Salzmann as chairman of the Cephalometric Workshop Committee. Graber stated, "The purpose of this report is to outline the essential technical details, such as equipment requirements, source and amount of radiation, problem of magnification, etc., to provide some of the morphologic and developmental framework that served to condition the evolution of clinical cephalometric criteria; to discuss the essentials of tracing headplates and the relative difficulty of locating some landmarks; to record the landmarks, measure points, planes, and angles that were accepted by the Workshop; and to present and interpret the cephalometric analysis that was synthesized by the Workshop for the clinician".

In 1959, Steiner[39] proposed the graph form of designed for diagnostic procedures and presented the ideal relationship of upper incisor to N-A and lower incisor to N-B for different A-N-B angle. By using the graph forms and the ideal relationship, Steiner tried to make diagnosis easier by setting up treatment goals which were more understandable for everybody.

Steiner further proposed the upper and lower incisor line and the upper and lower molar line to evaluate changes in the position of the teeth and the measurement pogonion to the line N-B to help prognosticate the position of the lower incisor teeth.

In 1960, Ricketts[10] discussed facial growth and development and changes during treatment. He especially stressed the possibiltiy of a "cephalometric blueprint", the prediction of growth and development and treatment results. He stated, "Natural growth of the skeletal bones comes to mind first when estimations of the future are being made, but its alteration with treatment must also be considered. --- The estimation procedure has thus been divided into 'static synthesis' for those cases in which growth is not expected and 'dynamic synthesis' for cases in which the advantages of growth are to be enjoyed".

Ricketts explained the measurements and the meanings, then he showed the results of the study that was made by determining 250 cases of serial cephalometric records. He used 250 cases, five groups, fifty patients in each group. There were two groups of non-treated cases and three groups of cases that had been treated. In the non-treated samples, there were fifty Class I cases and fifty Class II cases. The three treated samples, all Class II, were corrected by extraoral anchorage, intraoral anchorage, and a combination of these forces.

According to these finding, Ricketts explained the sequence for a short term prediction. The steps were as follows: 1) Establish cranial reference points. 2) Prognose behavior of the chin. 3) Estimate changes in the maxilla. 4) "Set up" the teeth cephalometrically. 5) Change the soft tissue of the profile.

In discussion, Ricketts stated, "There is a growing effort to attempt to estimate changes in the face and denture to occur during treatment. --- This procedure is one inital effort in this facet of cephalometrics. --- It is strictly information that is available, utilized with common sense".

In summary, he said, "Such terms as prediction, projection, prognosis, estimation, predetermination, and cephalometric setup have come to be related to anticipation of the future behavior of an orthodontic case. The term "cephalometric synthesis" has been employed to reach a putting-together of many related growth and anchorage factors to yield the product or the planned result in a new tracing".

In 1960, Ricketts[11] reported on 1,000 clinical cases in order to provide an adequate sample for description comparison and classification of clinical problems. Ricketts presented a system of five measurements from x-ray tracings, which was designed to provide a sensible method of informing the orthodontist of facial form and denture position. The five measurements were: 1) the facial angle, 2) the XY axis angle, 3) the measurement of contour and 4) and 5) the relationship of the upper and lower incisors to the A-Po plane.

Ricketts thought these angles and measurements proved to be indicators of facial depth, facial height and profile contour. He stated, "Classification by assigning numerical limits of the demoninators for chin location made for an easier and more informative communication of problems. The teeth were measured from the denture bases rather than to points outside the dental areas. The position of the lower incisor in relation to the A-Po plane was thought to be the key to communication of the problems with the anterior teeth".

Ricketts also studied changes with age in position of the lower incisor, facial contour, and lip relations from a cross-sectional viewpoint. Ricketts reported, "The average convexity decreased consistently from the deciduous dentition age to the full adult dentition age. At the same time, the lips become progressively more retracted in relation to the esthtic plane. However, the relationship of the lower incisor to the A-Po plane tended to be similar in the age samples studied".

In this article, Ricketts repeated the survey or analysis should be separated from the treatment planning. Ricketts stated, " I stressed the need for the concept that a survey or analysis was for the purpose of describing and understanding skeletal proportion and form. Treatment planning constitutes a separate subject embodying the factors of growth, tooth movement, and changes in function that subject - cephalometric synthesis - should be dealt with separately".

In 1960, Steiner[40] presented a case report that was treated by Dr. Lang and Steiner that demonstrated the use of cephalometric evidence in planning and assessing orthodontic treatment. In this article, Steiner compared the case with norms and showed the difference between the case and the norm. He also explained treatment planning with his method with the diagram on the analysis sheet.

In conclusion, Steiner stated, "We (Steiner and Lang) believe that this method of analysis does assist in treatment planning and in assessing changes that take place naturally and as a result of treatment. For treatment planning, it expresses problems so that they can be easily observed and therefore understood. It helps to make such decision as when to extract and when not to extract, and it gives an indication of what to extract. It helps to evaluate the results of different types of treatment - for instance, intraoral versus extraoral, stationary versus simple anchorage, and light forces versus heavy ones.

In 1963, Jarabak[7] published a book; "Technique and Treatment With Light-Wire Edgewise Appliances". In this book, Jarabak discussing the relation between the skeletal pattern and malocclusion also tried to predict the growth direction of the mandible. He introduced the Jarabak skeleto-dental cephalometric analysis that contains Björk, Steiner, and Downs analyses. He also reported the annual change of the anterior cranial base length, the posterior cranial base length, the ramus height, and the mandibular body length from age eleven to age eighteen for the prediction of the growth.

In 1966, Taylor and Hitchcock[41] published the Alabama analysis. In this study they used a heterogenetic sample to show "the children of Southern white ancestors". They said, "The South was settled predominantly by the Scottish, Irish, and English, with some Spainish and French influence. Even though the people of this area are heterogeneous, it stands to reason that it would be worth while to have a study based on samples from our area. Our hypothesis is that the ethnic background of Southern white children is different enough from that of children in other sections of the country to warrant a separate cephalometric standard and that a new standard probably might be used in the area for comparing children of Southern white ancestors".

In this study, Taylor and Hitchcock used seventeen boys and twenty-three girls who had normal occlusions and whose families were of predominantly Southern extraction for at least two generations, the age range of eight to fifteen. The samples also had pleasing or at least acceptable facial development and no orthodontic treatment. They took roentgen films by means of Margolis cephalostat (1943).[42]

They found no significant difference between the profiles of boys and girls in that age range. They selected sixteen measurements as statistically significant and clinically useful for the time being.

In 1974, Riolo, Moyers, McNamara and Hunter published, "An Atlas of Craniofacial Growth". This study contained eighty-three individuals, forty-seven males and thirty-six females with continuous attendance at the University school over the period, ranging from their sixth to sixteenth birthdays.

They reported seventy-four angular measurements and 113 linear measurements of the total sample for each year from the sixth through sixteenth. They did not discuss the meaning of the changes that were seen in the report.

B. JAPANESE STUDIES

In 1954, Kayukawa[15] published the roentgeno-cephalometric study of Japanese norms using the Downs analysis. In this study he not only introduced the possibility of the cephalometric measurement for research and treatment planning but also established the Japanese norms for the Downs analysis and discussed Japanese skeletal patterns and denture patterns. Kayukawa used twenty-three males and nine females, ages twelve to seventeen, with excellent occlusions, and he found Japanese certainly had different skeletal patterns and denture patterns but Kayukawa could not pinpoint the differences. Thus he posed the question, "What were the differences between Japanese and Caucasians, and what method could be adopted to pinpoint those differences?"

In 1955, Kayukawa[44] published his other cephalometric study using the same materials and analysis as those used at Northwestern University at the time. In this study, Kayukawa evaluated the S-N plane for reference and determined the meaning and the value of each measurement for analysis. In comparison to Caucasions, Kayukawa found Japanese had more convex type faces and a tendency toward antero-divergency of maxillary alveolar bone.

Two studies of Kayukawa, began the era of cephalometrics in Japan.

From the beginning, Japanese studies used the same orientation of the cephalostat as follows: the distance from the X-ray tube anode to the midline of the head is 150 cm. (@5 ft.) and the distance from the midline of the head to film surface is fifteen cm. (@6 in.)

In 1957, Iizuka and Ishikawa published two studies.[16,45] One study was the evaluation of Japanese norms and the other discussed how to identify the landmarks on the roentgeno-cephalogram.

The first study contained fifty males, average age of twenty-three years and seven months (from nineteen years eleven months to twenty years and eleven months) and fifty females, average age of nineteen years and seven months (from eighteen years five months to twenty-seven years four months) and was done by using the Downs, the Graber, the Donovan, the Tweed and the Wylie analysis. Iizuka and Ishikawa made comparisons between their results and the results of the original studies (American).

Considering sex differences, only the interincisal angle was found to be significantly different in this age group. They also stated differences between Japanese and Caucasians were as follows: 1) Japanese had a more retrusive pogonion, 2) Japanese had larger Frankfort-Mandibular Plane Angle, 3) Japanese had a smaller interincisal angle because of the forward tipping of mandibular incisors and the canting of the mandible itself and, 4) Japanese had a larger angle of convexity which might have been caused by a retrusive pogonion.

The second study used dried skulls and lead lines to show the landmarks on the cephalogram. This study established the identification of landmarks and the method of the tracings.

In the same year (1958), Miura, F., et al.[46] tried to show the differences of the denture pattern and skeletal pattern between people who had normal occlusions and people who had Class II division 1 malocclusions; at the same time they tried to show the differences between Japanese and Caucasians. They found no difference between Caucasians with normal occlusions and Japanese with normal occlusions when comparing the skeletal pattern of maxilla but Japanese had more retrusive and rotated mandible; on the denture pattern, the maxillary central incisor of Japanese was protrusive from maxillary apical base.

Also in 1958, Ootsubo[48] studied the skeletal and dental pattern of thirty-two females having a deep overbite and he made a comparison with fifty normal females. Ootsubo classified the malocclusion with a deep overbite by using the interincisal angle, because he found that the interincisal angle has a strong relationship with facial morphology.

In the same year, Iizuka[49] published a study dealing with the growth of the dentofacial complex of Japanese children, using the Hellman's dental stages as a scale for development. This cross-sectional study contained 232 cases. In this study Iizuka used a combination of the Downs analysis and the Northwestern (Graber and Riedel) analysis and showed the growth changes from the average age of five years to twelve years.

Iizuka discussed growth changes and found that the angular measurements showed no significant changes during four years of age to twelve years of age except the angular measurements related to incisors, and the growth changes were seen on the increase of size.

In the same year (1958), Someya[50] published a study of the skeletal pattern and denture pattern of mandibular prognathism using Class III material (seventy-five males and sixty-eight females) who had undergone surgical operation to correct the mandibular prognathism. In this study, Someya discussed the family history and the denture type (tooth shape, size, arch) and skeletal pattern by cephalogram. However, he could not determine the etiology of mandibular prognathism.

In 1959, Sakamoto[51] studied average growth of Japanese children with normal occlusion using Sella Turcica for special reference by cross sectional matter. In this study he used 272 children ages of four years to fourteen years, 127 males and 145 females plus ninty-nine adults.

Sakamoto stated his results as follows: 1) Generally, the face of Japanese grows forward and downward, 2) Facial patterns change gradually throughout the whole growth period. The upper face is most stable while that of the lower shows the greatest variability in depth, 3) No significant difference is found concerning the size of the face between males and females until about ten years of age. In later than that, however, the growth increment is greater in males than in females, 4) The Japanese show a longer face in absolute size as well as in facial pattern and more retrognathic than Caucasions.

In the same year (1959), Yamauchi[52] introduced the idea of a beautiful face in his study and determined the factors of beauty by using selected subjects who were chosen from various occupational groups. In this study, Yamauchi completely neglected good occlusion. He concluded this study as follows: the "beautiful face" group generally had a larger interincisal angle than the normal group; and, the incisors of the "beautiful face" group were less labially tipped; otherwise there were no significant differences between the "beautiful face" and normal on the cephlometric measurements.

In 1960, Miura, F., et al.[53] studied adult Japanese female using Coben's method. This study contained fifty female subjects, average age of nineteen years and seven months used by Iizuka and Ishikawa in their study in

1957. Miura introduced the parallelogram that was a modified Wiggle method to show the vertical and horizontal segments. They found the difference of facial structure between Japanese and Caucasians was not significant in the depth of the middle face (N-Ba), though differences in each segment contributing to the middle face were found. Japanese have however, more retruded mandibles than Caucasians. The ratio of anterior facial height to posterior facial height and the ratio of anterior lower facial height to anterior upperfacial height in Japanese was greater than Caucasian.

In 1961, Kuwahara, M.[54] published a longitudinal study of dentofacial growth, ages seven to ten years old. The subjects were divided into four groups, by using Ootsubo's standard (1958): normal (Class I molar relation with no abnormality, overjet overbite within 1 S.D.); maxillary prognathism (Class I and Class II molar relationship and overjet and overbite over + 1 S.D.); deep overbite (overbite over +1 S.D.) and mandibular prognathism (negative overjet with Class I and Class III molar relationship). She stated the result of this study as follows: 1) In the group of normal occlusion, three types of growth patterns were observed; a) Backward divergent type b) Forward convergent type, and c) Straight type. 2) It was clear that the dentofacial pattern may alter throughout this period. During this period the facial depth increased as the posterior portion of the face increased, and the facial height also increased at the ramus and upper anterior portion. 3) In the normal occlusion group, positional relationship of the denture to the cranium was relatively stable throughout this period.

In the same year (1961), Yamauchi and Matsumoto[55,56] published their studies about the "beautiful face" or "acceptable face" to determine the special pattern or attributes of a beautiful Japanese face using the Facial plane (N-Pog) for a reference plane. He said about the "beautiful face", today people generally prefer or appreciate the faces which have some amount of convexity with each component of the face in balanced position and morphology rather than a straight profile which was presented by Downs as his norms.

In 1963, Ishizawa and Takada[57] studied thirty-seven male adults without any abnormality of the neuromusculature in the oro-facial region. They found high correlation coefficients between the outline of the lip structure and the shape of the underlying hard tissue. They also determined the average thickness of upper lip and lower lip at the level of mucolabial fold.

In 1964, Yamauchi, et al.[58] studied sixty-nine Japanese adults, thrity-one males (aged twenty-one to twenty-eight years) and thirty-eight females (aged eighteen to twenty-five years) with normal occlusions and acceptable profiles. Yamauchi et al. made a comparison to the standards of Iizuka and Ishikawa (1957).[45] They stated, "In our subjects, the sex differences were suggested in the linear measurements and not in the angular measurements".

In the same year (1964), Yamauchi, et al.[59] published a study comparing dentulous young adults (thirty-three males twenty-one to twenty-eight years old and forty females eighteen to twenty-five years old) with edentulous older adults (twenty males fifty to seventy-two years old and twelve females fourty-eight to sixty-eight years old). They reported the difference between these groups as follows: 1) In the maxilla, both groups showed a constant position of the artifical and natural molars and incisors, however, 2) In the mandible no such proportional relationship was noted. In the maxilla, the mean distance from anterior alveolar ridge to the nasal floor (ANS-PNS line) of the edentulous adults was about two-thirds as long as the mean of the distance from prosthion to the nasal floor, or about twice as long as the mean distance from point A (Downs) to the nasal floor of the dentulous young adults. In the mandible, the mean distance from the anterior alveolar ridge to the mandibular plane of the edentulous adults was nearly equal to the mean distance from point B (Downs) to the mandibular plane of the dentulous young adults. 3) The difference between the edentulous adults and the dentulous young adults in the position of the mandible to the cranial base and maxilla, was dictated by mandibular form.

In 1965, Miura, et al.[60] published cephalometric standards for Japanese according to the Steiner analysis using forty males and fifty females ages seven years six months to twelve years four months, average age being ten years nine months. Miura, F., et al. showed that there were no significant differences between the mean values of the measurements of males and females at this age. They stated, "retroposition of the mandible and labial inclination of the maxillary and mandibular incisors were pointed out as being a typical thing of the Japanese face".

In the same year (1965), Miura, M.[61] studied point C, proposed by Coutand (1956)[62] as a measuring point for facilitating observation of harmony in the vertical anteroposterior relationship of the basal bone of the maxilla and mandible. Using Japanese adults (fifty-seven males and fifty-eight females), she found that in the cases which did not have abnormal relationships of maxillary and mandibular basal bones, point C came closer to the bisecting line of the angle that was formed by the nasal plane and the mandibular plane.

In 1967, Susami[63] published a cephalometric study of dentofacial growth in mandibular prognathism using 409 Class III subjects (179 males and 230 females) from the cases in decidious dentition to adult age. In this study

Susami used Class I malocclusion subjects (186 males and 188 females) as the control group. He discussed the growth pattern and developmental pattern of Class III children.

In the same year (1967), Ito (Keiichi) and Suematsu[64] did a roentgeno-cephalometric study of the soft and hard tissue profiles of thirty-eight Japanese females, ages eighteen years to twenty-five years, who had good profiles, using two lines as the reference. The first line connected the point of subnasion and the point of the greatest concavity of the nose and the second line was drawn through point Sn and was perpendicular to the first line. They found the following; in depth and height, the dimensions from point A to point Sn were smaller than from the other points to Sn and the variation between the individuals was relatively small. 2) The difference between individuals on the lower face profile was larger than on that of the upper facial profile. This difference was greatest in the chin region.

In the same year (1967), Yamauchi, et al.[65] published a similar study about soft tissue and hard tissue profiles of Japanese containing thirty adult males, ages twenty-three years to twenty-six years, and made comparisons with the results of Ito and Suematsu to determine the sex difference. They stated; 1) In depth and height, individual variations and sex differences of the lower facial profiles were larger than the upper face. 2) The sex difference on upper facial profile were larger in height than depth. 3) From supramenton to the chin region the male sample was more posteriorly oriented than the female by refering to the soft tissue nasion subnasal plane. 4) The individual variations and the sex differences of the tip of the nose using Sn as reference were the smallest in all measurements. 5) The individual variation in height and depth measured from point A, was relatively smaller than the measurement from the other point. 7) The thickness of the tissue of the upper face and the upper lip in the male samples were larger than those of the female samples.

In 1968, Takahama, et al.[66] discussed the tracing errors and measurement errors. They stated the standard error of the measurements were less than $\pm$ 0.8 mm. in length.

In 1969, Sebata, et al.[67] studied the correlation between the angle A-N-B VS. Frankfort plane to upper central incisor, and Frankfort plane to lower central incisor. In this study they used fifty males and fifty females over twenty years of age with the conditions as follows; 1) acceptable profile individual 2) no crowding in both arches 3) no functional abnormality in the occlusion, tongue and lips. Because of those conditions, the authors could not avoid choosing samples with a skeletal discrepancy or Class II individuals or Class III individuals. They found some correlations between A-N-B and Frankfort to lower central incisor both in males and females.

The same group published another study[68] comparing normal occlusion and malocclusion using the first study as a control. They divided the malocclusion group into three: crowding, reversed occlusions (anterior cross bite), and maxillary protrusions. Each group contained fifty males and 100 females including harmonious profile individuals and disharmonious ones. Their results were as follows: 1) The mean value of the angle A-N-B did not change between the total abnormal group and normal group, but significant differences were seen in the mandibular protrusion group and the maxillary protrusion group compared to the normal group. 2) In all of the abnormal groups, the mean value of the Frankfort plane to upper central incisor angle showed a greater inclination to the labial side than normals, if the group had good-looking profiles. On the other hand, the Frankfort plane to Lower incisal angle remained unchanged in abnormal totals, but when they were divided into a harmonious group and a disharmonious group they showed opposite results between the harmonious group and the disharmonious group, such as, harmonies tend toward larger angles and disharmonies were smaller.

In the same year (1969), Yogosawa[69] studied the relationship between dento-skeletal structure and soft tissue profiles using fifty male adults (ages eighteen to twenty-seven years) who had normal occlusions, and fifty male adults (age of eighteen years to twenty-seven years) who showed maxillary protrusions (overjet 5 mm. or more). His results were as follows: 1) Generally speaking, in the maxillary protrusion group, the soft tissue profile showed less tendency to assume the form of contour of hard tissue than the normal occlusion group. 2) In the relaxed position, the thickness covering the lower face, and the length of the upper and lower lips showed a trend in the maxillary protrusion group towards the normal occlusion group. 3) Various portions of the perioral soft tissue movements, from the relaxed position to centric occlusion with closed lip position were different between the normal and the maxillary protrusion groups. In general, greater movements were found in the maxillary protrusion group than in the normal occlusion group. 4) In general, as in the vertical movements (rest position to C-O) of the lower lip, the thickness of the soft tissue on point B was increased and the thickness of the soft tissue on the skeletal pogonion was diminished.

In the same year (1969), Iwasaki, et al.[70] studied Class I, Class II and Class III adults to determine the difference of skeletal and dental pattern between each malocclusion. They used twenty people with normal occlusions for control and twenty-five people in each malocclusion group. They also made comparisons with their normal group and the Graber study and Downs study. The results were as follows: a) Japanese had larger mandibular plane angles. b) Japanese had a larger convexity and A-N-B but not as large as reported by Kayukawa, Iizuka and Ishikawa. c) Generally, Japanese incisors were more labially tipped, especially lower incisors tended to tip labially.

In the same year (1969), Shishikura71 studied ninety-six Class I adult patients and thirty-six male adults with good profiles to determine Japanese norms for the Steiner analysis. He presented the Ideal for Japanese adult based on the Steiner analysis as followed; A-N-B 4 degrees upper on to N-A line 5 mm. in distance, 21 degrees in angle and Lower One to N-B line 9 mm. in distance, 29 degrees in angle. He stated, using Ricketts ethetic line as reference, upper lip located 1 mm. posteriorly and lower lip located 0.5 mm. anteriorly from the line.

In 1970, Naruse72 studied the morphology of Japanese adults who had balanced profiles using standard oriented facial photos and roentgen-cephalometrics. He used fifty-three males and fifty-one females with anatomically normal occlusions as subjects. He then chose twenty males and twenty females with balanced profiles. He stated the results as follows: 1) comparing male profiles and female profiles in depth and height, females had flatter profiles 2) The angular measurement of the soft tissue on the standard oriented facial photo showed some sex difference which could not be seen the angular measurement of hard tissue.

In the same year (1970), Sebata, et al. published two studies[73,74] using the same material as their 1969 study. Their earlier study concerned the relationship between maxillary and mandibular central incisors, and the Mandibular plane and nasal floor. They discussed the difference between the relationship in the normal occlusion group and the relationship in malocclusion groups. The later study concerned the relationship between the Frankfort plane, S-N plane, nasal floor and mandibular plane. In these two studies they found there were no significant differences between normal occlusion groups and malocclusion groups in the relationships between the Frankfort plane; S-N plane, nasal floor and mandibular plane, but the relationship between nasal floor and maxillary incisor showed slight sex differences.

In 1971, Iwasaki, et al.[75] studied the difference between Class I anterior crossbites and Class III using mixed dentition subjects, Hellman's dental stage III-A to III-B (seven years to eleven years ten months old with the average age of nine years two months old), eighteen cases of Class I anterior crossbite, eighteen cases of Class I - Class III border line, and eighteen cases of Class III. They found significant differences in jaw morphology between Class I anterior crossbites and Class III anterior crossbites.

In 1972, Aoki[76] published a cephalometric study of the profile of young adults of Japanese and American (Caucasian origin) from the viewpoint of prosthetics. Aoki used four groups, Japanese males (average of twenty-four years old), Japanese females (average age of twenty-two years old), American (Caucasian) males (average age of twenty-three years old), and American (Caucasian) females (average age of twenty-five years old), each group had twenty people who met the conditions as follows: 1) normal dentition and occlusion that was, not seriously deviated, malposed, abnormally abrased or elongated and incompletely erupted teeth. 2) no previous history of prosthetic restorations and/or missing teeth (with the exception of the third molars). 3) no history of orthodontic treatment. Aoki discussed the findings from the view point of the necessity for prosthetic dentistry, and he listed the following interesting findings --- 2) Angles formed with the Ricketts Esthetic line (Frankfort plane, occlusal plane, mandibular plane, facial plane) showed significant differences between the two groups of male and two groups of female and two total Japanese and total American groups. --- 4) "A coefficient relationship existed in the interval between the Occlusal and the Frankfort mandibular plane angle". When the Occlusal plane approached a parallel relation with the Frankfort plane, the mandibular plane angle tended to decrease.

In the same year, Mitani, H.[77] published his first report of a longitudinal growth study. This study dealt with the analysis of growth increments of several components of the human face as studied from several lateral cephalometric roentgenograms of thirty Japanese, seventeen males and thirteen females. Each set of roentgenograms were composed of eight year series from the age of seven to fifteen years and the method of gaining measurements was mainly based on the Coben's coordinate system. Mitani, H. compared his results with the results of Coben (1955), and he stated as follows: The results indicated that the remarkable growth of the mandible would be the primary contributor to the facial configuration at puberty, yet there was a definite sexual and racial difference in terms of annual increments of growth.

In 1973, Asai[78] published his study of the average and individual growth of maxillo-facial complex with longitudinal cepalometric roentgenograms of fifty-one Japanese, thirty-one males and twenty females at the age of twelve, fourteen and seventeen. He summarized the sex difference in his study as follows: At twelve years of age, sex difference was very little. However, the differences become gradually apparent after twelve years of age by the greater amount of growth in males.

In 1974, Namura and Muneta[79] published their study of the Holdaway ratio for Japanese. This study involved sixty Japanese adults possessing normal occlusions, Class II division 2, and Class III. They suggested a 4 to 1 relation for the Japanese Holdaway ratio.

In the same year (1974), Mitani, H.[80] published the second report of his longitudinal study of Japanese children. The analysis was performed for annual change of each growth curve to show some common patterns of growth rate. Each curve in both males and females exhibited a peak which indicated the pubertal spurt. The female ratio generally exceeded that of the male of each component indicating that the female matured more rapidly than the male. The changing rates of the facial depth and height were highly correlated to each other showing an orderly relationship.

In the same year (1974), Iwasaki, et al.[81] determined the Tweed triangle for Japanese with normal occlusions. They also attempted to establish the Z angle (Merrifield 1966) to study facial esthetics. They used eighteen male and eighteen female subjects with normal occlusions and good facial harmony. They selected twenty subjects whose facial forms were judged to be good from that normal occlusion group. Those groups were compared with the Class II division 1 group and the Class III group. Each group had twenty subjects. As the results of the study, Iwasaki et al. suggested a new Tweed triangle for Japanese as FMA 27.28 degrees, IMPA 95.50 degrees FMIA 57.22 degrees.

In 1975, Matsuura[82] studied Japanese adults with normal occlusions and preferable profiles from a clinical standpoint. He chose thirty-six males and thirty-six females from 2024 Japanese adults possessing normal occlusion. He did not find any significant difference when comparing sexes. He also compared his results with those of other Japanese and Caucasian studies. In this study, Matsuura tried to establish a new treatment goal for Japanese.

In 1977, Ito (Kazue),et al.[83] determined the relationships between the relative position of maxillary apical base to mandibular apical base and the inclination and position of the incisors. They also assessed the influences of the inclination and position of the incisors to facial esthetics. They used lateral cephalograms of the forty-three patients who were treated orthodontically and were in retention for at least one year. They found the interincisal angle revealed no significant correlation with the maxillary and mandibular apical base relation. They found the use of A-B plane as a reference line to be meaningful for treatment planning.

The same year Mitani, H.[84] published the third study of his series of longitudinal study of the Japanese children using the same material. This study dealt with the analysis of the constitutional changes of the several components of the human face during the pubertal growth period. He stated each facial component showed a continuous but not constant proportional change to the total depth or height during the period studied, but the degree of the change was not always coincident to the other. He also found the cause of such change was mainly attributed to the remarkable growth of the mandible that occurred during this period, but the growth of the posterior cranial base (Ba-S) seemed to be intimately related to it.

In 1978, Uesato, et al.[85] published a study of the Steiner's analysis norms for Japanese and Japanese-Americans. They used twenty-five Japanese boys and twenty-five Japanese girls ranging in age from eleven to eighteen years, the average age being fourteen years. These samples were selected on the basis of what they thought were acceptable occlusions, incisor relationships and balanced facial profiles. In this study they tried to make the "ideal reference norm" for Japanese and Japanese-Americans. One case was selected from the fifty cases as being the "best", that is, as meeting the requirements of their concept of good occlusion, incisor relationship, and balanced facial profile.

CHAPTER III.

MATERIALS AND METHODS

A. MATERIALS

The tracings of oriented roentgeno-cephalograms were chosen from the Matsumoto Dental College Orthodontic Department. Dr. Tadao Nakago, Professor and Chairman of the Department of Orthodontics at Matsumoto Dental College, made possible a series of tracings used in a longitudinal growth study there. Those tracings contained thirty male and twenty female, seventeen year olds. Originally those tracings were made from a series of the oriented roentgeno-cephalograms that were taken for a longitudinal study of growth and development. The subjects were randomly sampled from a school which was in Osaka, Japan with conditions as follows:

1) No abnormal signs were seen in the annual medical examination.
2) No remarkable large overjet nor overbite was observed.
3) There were no missing nor supernumerary teeth at the anterior portion of the dental arch.

4) There was no remarkable rotation nor remarkable malposition of teeth in any dimension.

5) There were no caries nor wearing of crown or bridges at central incisors.

6) No orthodontic treatment had been applied before and during the sampling term.

The original roentgen films were not open to the public: because of the fact, this study had to be done by using those tracings only. Original tracings were made anatomically by Asai for his study following the methods of Iizuka and Ishikawa (1957).45

Every measurement was performed three times by the author and the middle value of the three recorded. The difference of the three measurements were usually within 1 mm. or 1 degree.

The measurements were made by the author using a Unitek Cephalometric Protractor and Dome Cephalometric Anatomical Template. Those were accurate to 1/2 degree and 1/2 mm.

There are slight differences between Japanese and American standard orientation of a cephalogram machine. The standard for the Japanese is 150 cm. from the X-ray tube anode to the center of the subject and 15 cm. from the center of the subject to the film surface. The American is 5 feet (152.4 cm.) from the X-ray tube anode to the center of the subject and 15 cm. from the center of the subject to the film surface. But this difference appears on the film surface as less than 0.5% of the length, therefore the difference is negligible.

B. POINTS AND PLANES

POINTS

The following landmarks were used in this study (Fig. M-1):

1) N Nasion - The Junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose.

2) S Sella turcica - The center of the pituitary fossa of the sphenoid bone.

3) Ar Articulare (Articulare Posterior) - The point of intersection of the inferior cranial base surface and the averaged posterior surface of the mandibular condyles.

4) Go Gonion - The midpoint of the angle of the mandible. However in this study the Gonial Intersection, that was the intersection of the mandibular plane with a plane through Articulare Posterior and along the portion of the mandibular ramus inferior was used.

5) Me Menton - The most inferior point on the symphiseal outline.

6) P Porion - The point located at the most superior point of the external auditiory meatus.

7) Or Orbitale - The lowest point on the average of the right and left borders of the bony oribt.

8) A A Point - The most posterior point on the curve

of the maxilla between the anterior nasal spine and supradentale.

9) B — B Point - The most posterior point to a line from Infradentale to Pogonion on the anterior surface of the symphiseal outline of the mandible.

10) Pog — Pogonion - The most anterior point on the contour of the bony chin, determined by the tangent through Nasion.

11) Ba — Basion - The most inferior point on the anterior margin of foramen magnum.

12) ANS — Anterior Nasal Spine - The tip of the median sharp bony process of the maxilla at the lower margin of the anterior nasal opening.

13) PNS — Posterior Nasal Spine - The most posterior point at the sagittal plane on the bony hard palate.

14) Gn — Mechanical Gnathion - The intersection of Facial Plane and Mandibular Plane.

15) CF — The intersection of Frankfort Plane and Pterygoid Vertical.

The definition of those points were from AN ATLAS OF CRANIOFACIAL GROWTH 1) to 13) and from ROCKY MOUNTAIN DATA SYSTEMS MANUAL 14).

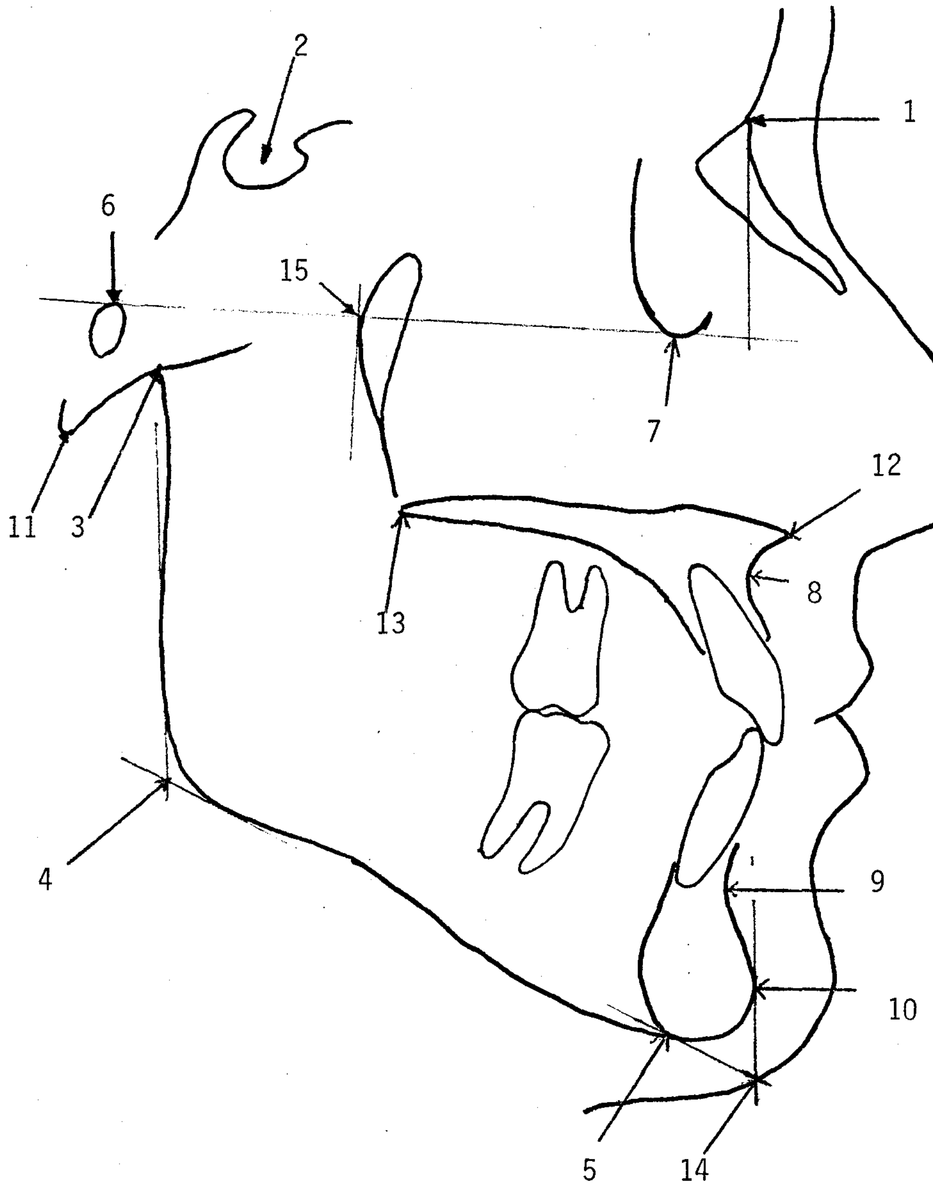


Fig. M-1

POINTS

1) Nasion

2) Sella turcica

3) Articulare

4) Gonion

5) Menton

6) Porion

7) Orbitale

8) A Point

9) B Point

10) Pogonion

11) Basion

12) Anterior Nasal Spine

13) Posterior Nasal Spine

14) Mechanical Gnation

15) CF Point

PLANES

The following Planes were used in this study (Fig. M-2A, M-2B):

1) S-N Plane: Sella-Nasion
2) Frankfort Plane: Porion-Orbitale
3) Palatal Plane: Anterior Nasal Spine - Posterior Nasal Spine
4) Occlusal Plane (Steiner): The midpoint of the line connecting the incisal tip of the mandibular central incisor and the incisal tip of the maxillary central incisor.
5) Mandibular Plane (Downs): Menton to the lower border of the mandible.
6) Pterygoid Vertical: A line perpendicular to Frankfort Plane through the distal of Pterygo-palatine fossa.
7) Ba-N Plane: Basion - Nasion
8) Facial Plane: Nasion-Pogonion
9) Y axis: Sella-Mechanical Gnathion
10) A-Po Plane: Point A-Pogonion
11) N-A Plane: Nasion-Point A
12) N-B Plane: Nasion-Point B

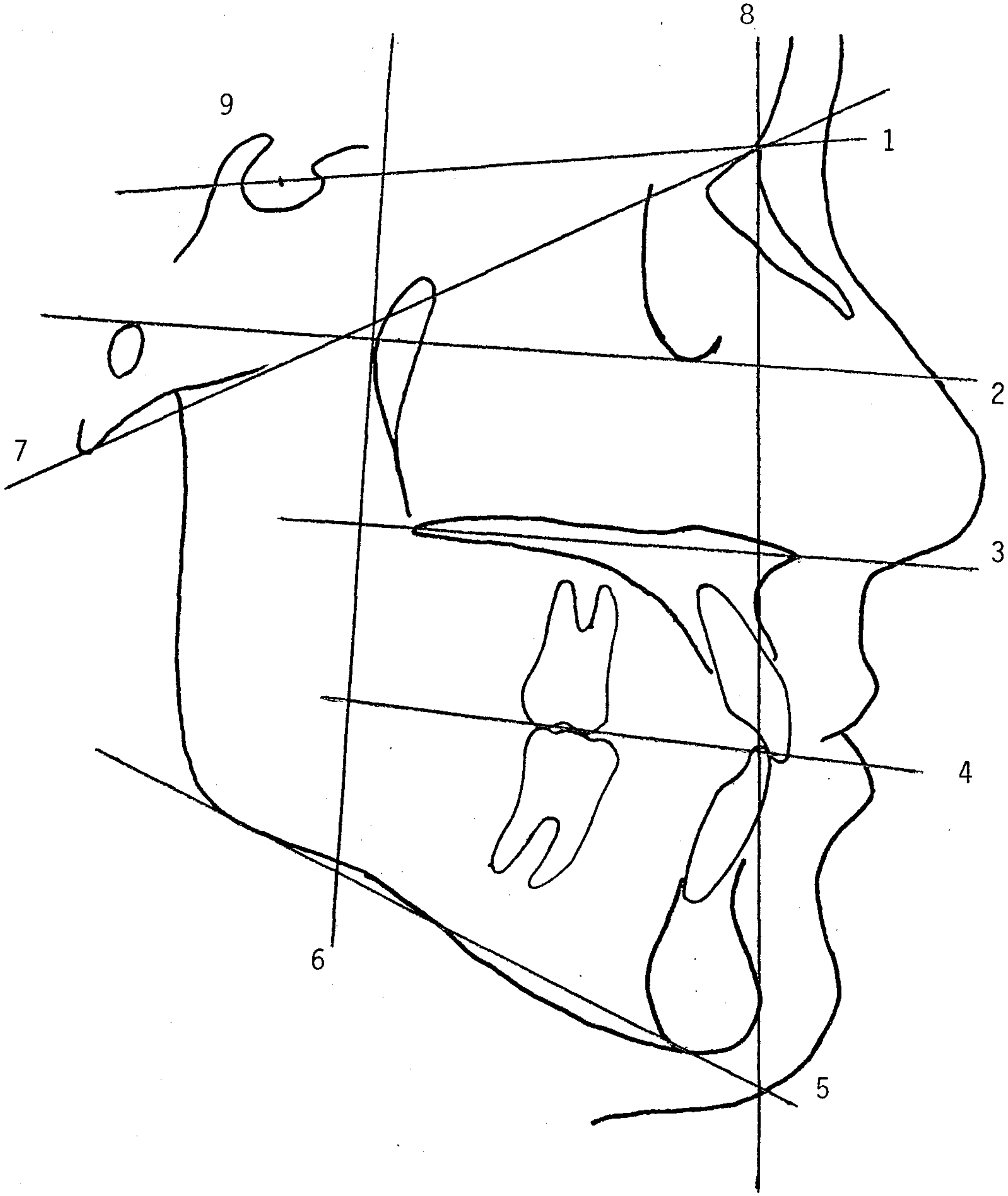


Fig. M-2A

PLANES

1) S-N Plane

2) Frankfort Plane

3) Palatal Plane

4) Occlusal Plane (Steiner)

5) Mandibular Plane

6) Pterygoid Vertical

7) Ba-N Plane

8) Facial Plane

9) Y axis

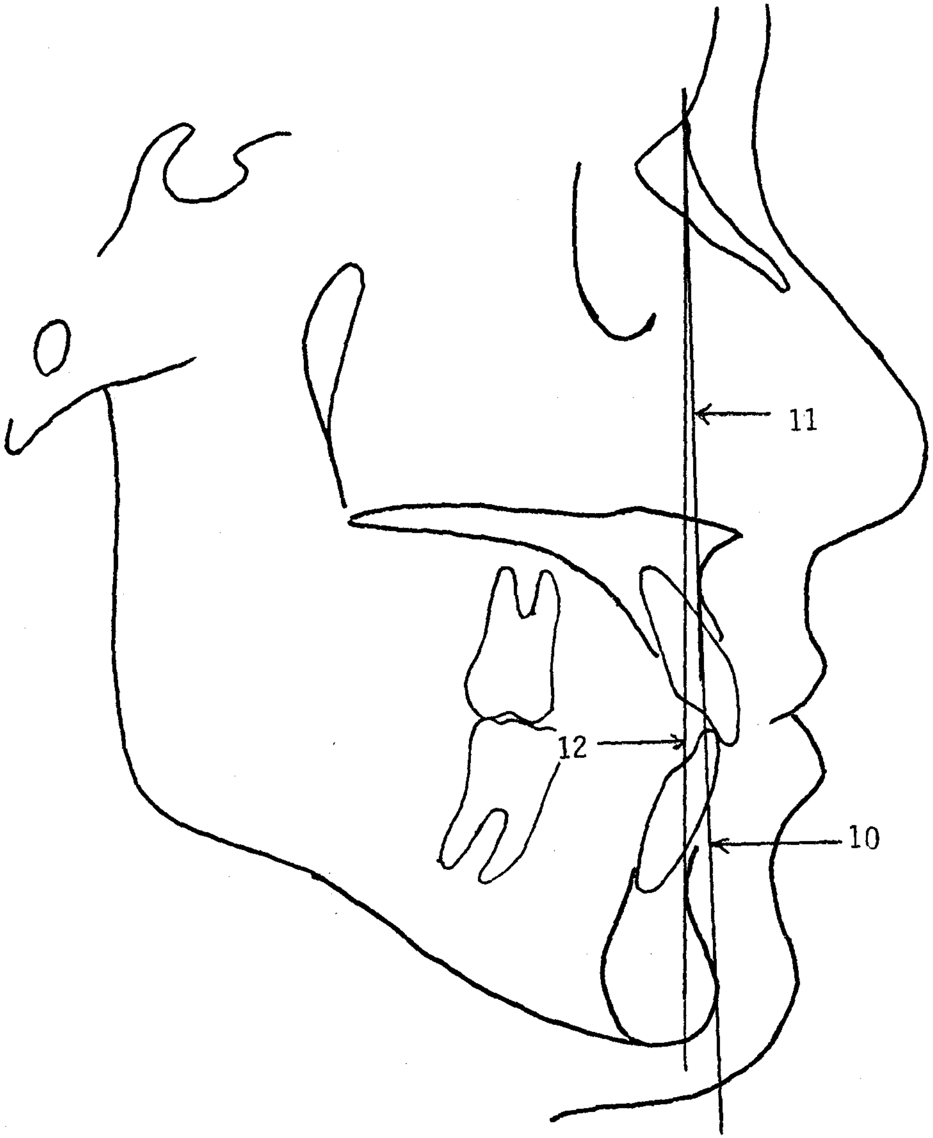


Fig. M-2B

PLANES

10) A-Po Plane

11) N-A Plane

12) N-B Plane

C. ANALYSES

Because it is more dependable to use several analyses at the same time, the Downs, the Steiner, the Bjork, the Jarabak, and the Ricketts analyses were used. Also because of the limitation of the landmarks which were contained in the tracings, it was not possible to use some measurements.

The measurements used in this study were as follows:

FROM DOWNS ANALYSIS (Fig. M-3):

1) Facial Plane Angle - The inside inferior angle formed by the intersection of the Frankfort Plane and Facial Plane
2) Angle of Convexity - The angle formed by the intersection of a line from the Nasion to Point A with a line from Point A to Pogonion.
3) Frankfort Mandibular Plane Angle - The angle formed by Frankfort Plane and Mandibular Plane.
4) Y axis - Originally the angle formed by Frankfort Plane and a line from Sella to Gnathion. In this study, Mechanical Gnathion was used for Gnathion.
5) Interincisal Angle - The angle formed by the long axis of the maxillary central incisor and the long axis of the mandibular central incisor.
6) $\overline{1}$ to Mandibular Plane Angle - The angle formed by the long axis of mandibular central incisor and Mandibular Plane.

7) Distance 1 to A-Po - The distance from the A-Po plane to the tip of the maxillary central incisor.

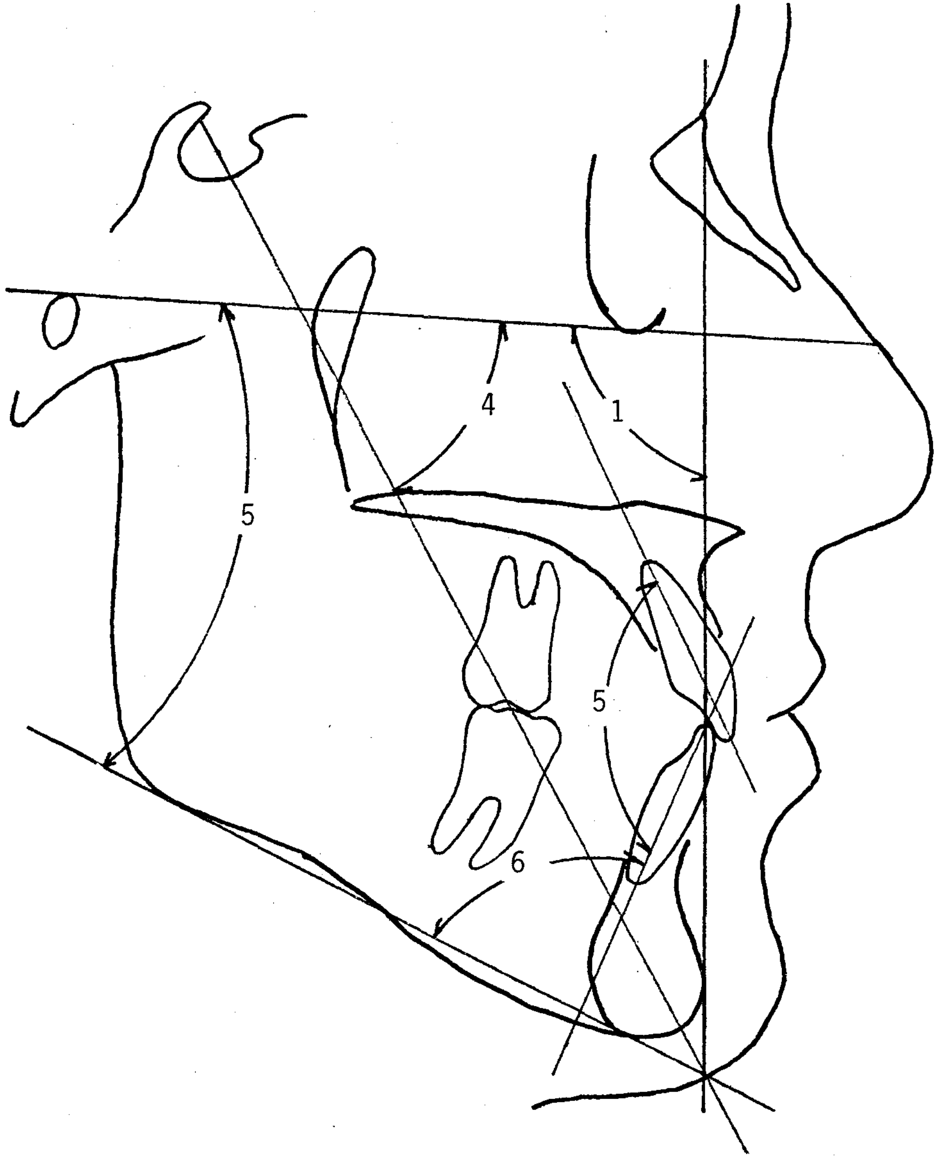


Fig. M-3 DOWNS ANALYSIS

1) Facial Plane Angle

2) Angle of Convexity

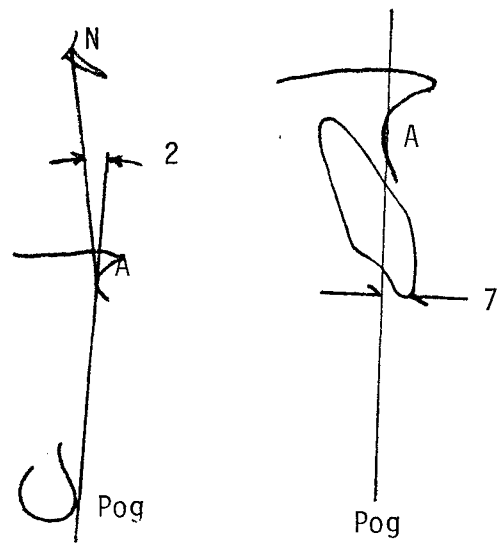
3) Frankfort Mandibular Plane Angle

4) Y axis

5) Interincisal Angle

6) $\overline{1}$ to Mandibular Plane Angle

7) $\underline{1}$ to A-Po Distance



FROM STEINER ANALYSIS (Fig. M-4):

1) S-N-A: S-N-A

2) S-N-B: S-N-B

3) A-N-B difference: A-N-B

4) $\underline{1}$ to N-A (mm.): N-A to the most anterior point of the maxillary central incisor crown

5) $\underline{1}$ to N-A (degree): Angle between N-A and axis of the maxillary central incisor.

6) $\overline{1}$ to N-B (mm.): N-B to the most anterior point of the mandibular central incisor.

7) $\overline{1}$ to N-B (degree): Angle between N-B and axis of the mandibular central incisor crown.

8) Po to N-B: The distance between N-B line to Pogonion

9) Occlusal Plane to S-N: Angle between Occlusal Plane and S-N.

10) Go-Gn - S-N: Angle between Gonion - Gnathion and S-N, in this study, Mandibular Plane was used instead of Go-Gn.

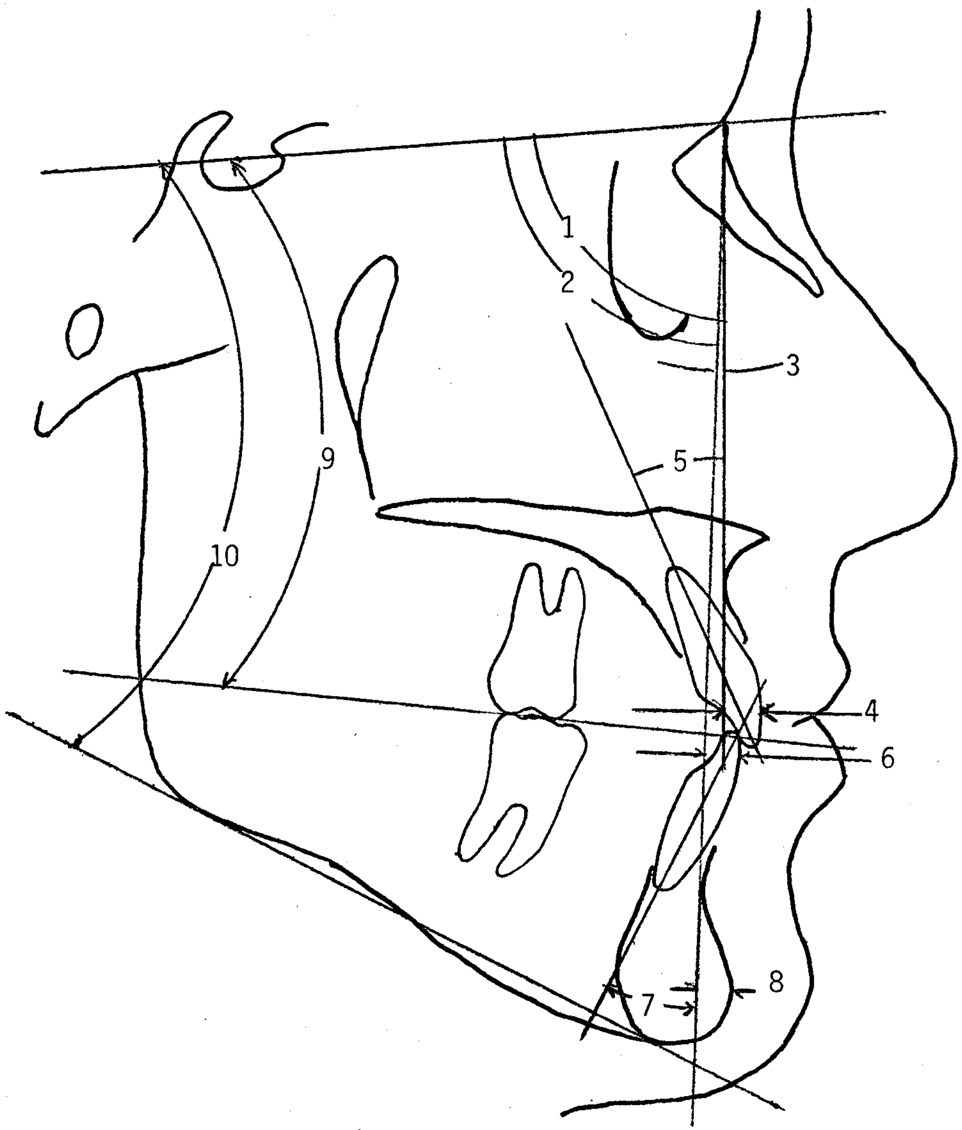


Fig. M-4

STEINER ANALYSIS

1) S-N-A
2) S-N-B
3) A-N-B Difference
4) $\underline{1}$ to N-A (mm)
5) $\underline{1}$ to N-A (degree)
6) $\overline{1}$ to N-B (mm)
7) $\overline{1}$ to N-B (degree)
8) Po to N-B
9) Occlusal Plane to S-N
10) Go-Gn-S-N

FROM RICKETTS ANALYSIS (Fig. M-5A, M-5B):

1) Convexity: The perpendicular distance between the Point A and the Facial Plane

2) Upper Molar Position: The perpendicular distance from the Pterygoid Vertical to the distal of the maxillary first molar.

3) Mandibular Incisor Protrusion: The perpendicular distance from the tip of the lower incisor to the line defining the jaws, the "A-Po" Plane.

4) Maxillary Incisor Protrusion: The perpendicular distance from the tip of the maxillary incisor to the "A-Po" Plane.

5) Mandibular Incisor Inclination: The angle between the long axis of the lower incisor and the "A-Po" plane.

6) Maxillary Incisor Inclination: The angle between the long axis of the upper incisor and the "A-Po" Plane.

7) Facial Depth: The angle between the Facial Plane and Frankfort Plane.

8) Facial Taper: The angle between the Mandibular Plane and the Facial Plane.

9) Mandibular Plane Angle: The angle between Frankfort Plane and the Mandibular Plane.

10) Maxillary Depth: The angle formed by the Frankfort Plane and the plane formed by Nasion to Point A.

11) Maxillary Height: the angle formed by the points Nasion, CF and Point A.

12) Palatal Plane Angle: The angle between Frankfort Plane and Palatal Plane.

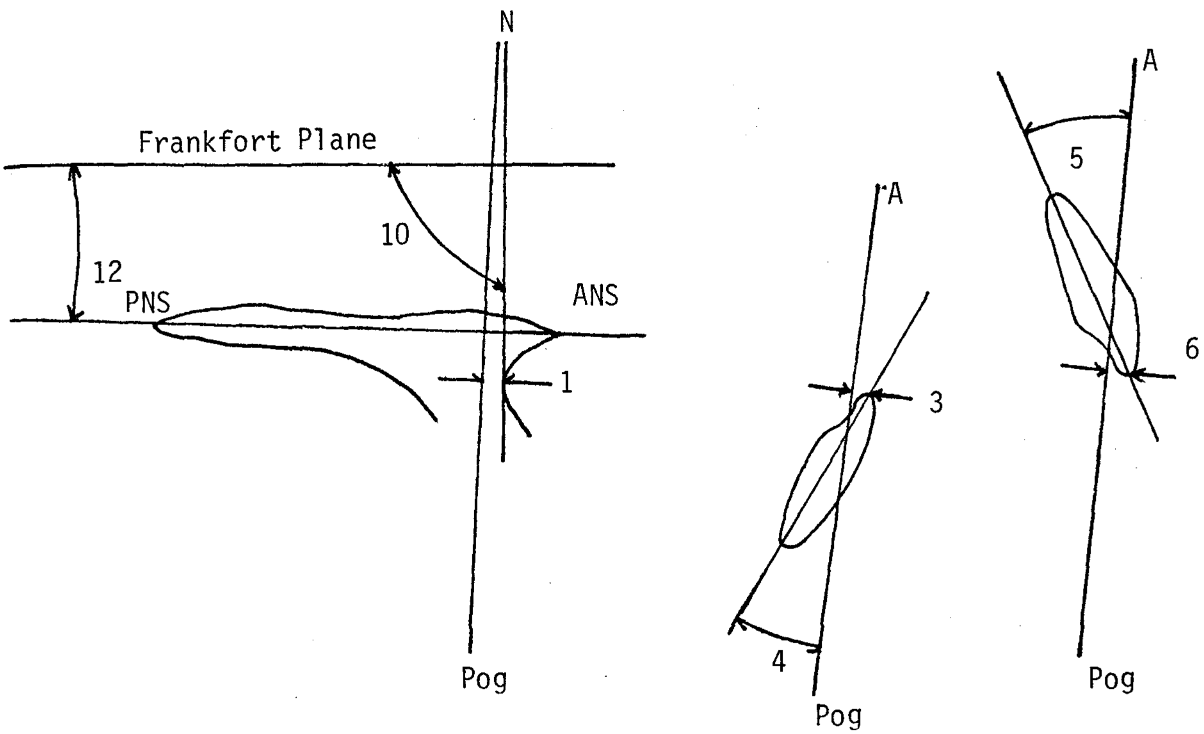
13) Cranial Deflection: The angle between the Basion Nasion and Frankfort Plane.

14) Porion Location: The distance between Porion and the Pterygoid Vertical

15) Interincisal Angle: The angle formed by intersection of the the long axis of the maxillary and mandibular central incisors

16) Posterior Facial Height: The distance between Gonion and CF (Here Gonion means the intersection of the posterior border of ramus and Mandibular Plane)

Fig. M-5A RICKETTS ANALYSIS



1) Convexity

3) Mandibular Incisor Protrusion

4) Mandibular Incisor Inclination

5) Maxillary Incisor Protrusion

6) Maxillary Incisor Inclination

10) Maxillary Depth

11) Palatal Plane Angle

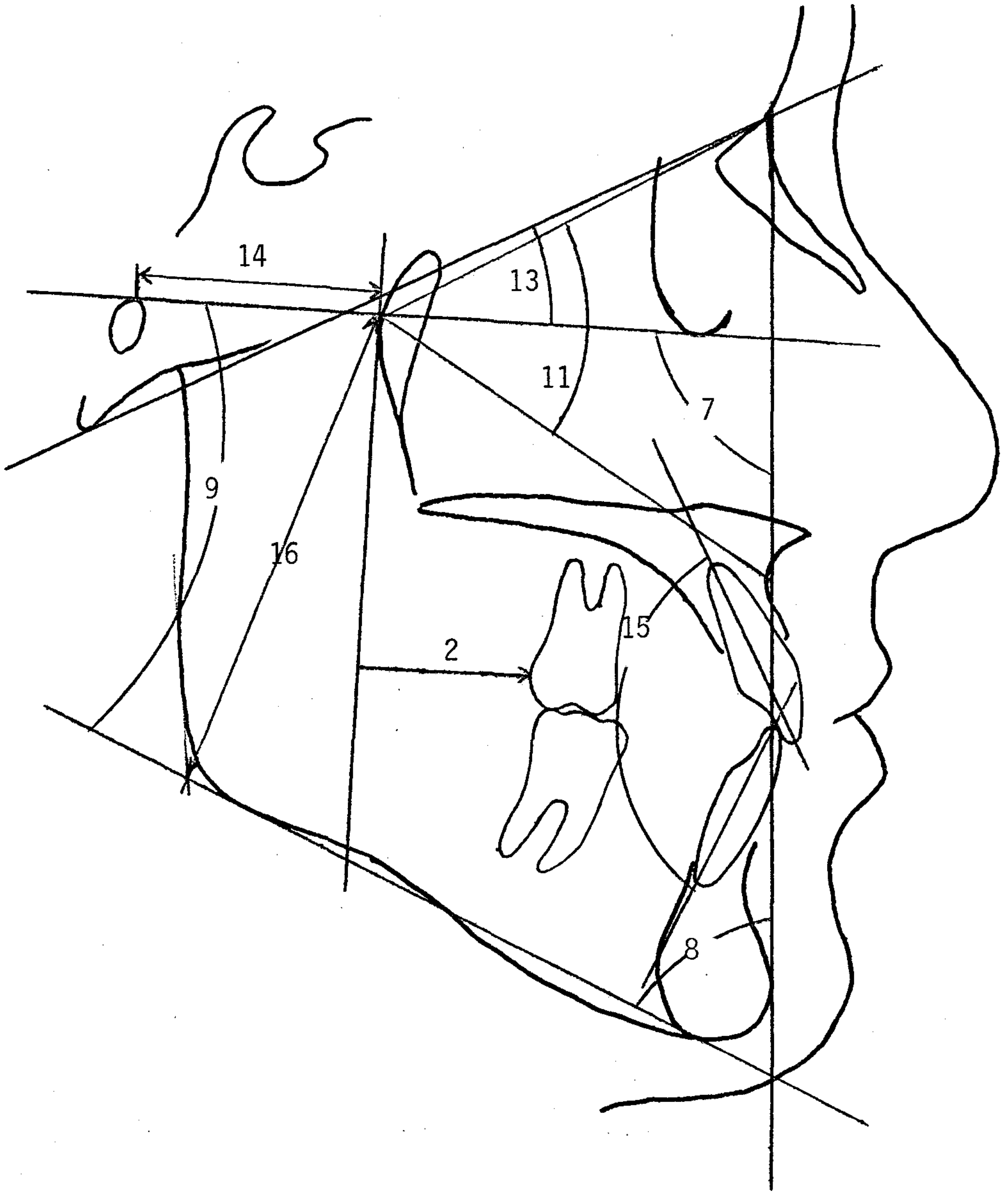


Fig. M-5B

RICKETTS ANALYSIS (cont')

2) Upper Molar Position

7) Facial Depth

8) Facial Taper

9) Mandibular Plane Angle

11) Maxillary Height

13) Cranial Deflection

14) Porion Location

15) Interincisal Angle

16) Posterior Facial Height

FROM BJÖRK (Fig. M-6):

1) Saddle Angle: N - S - Ar

2) Articular Angle: S - Ar - Go

3) Gonial Angle: Ar - Go - Me

4) Anterior Cranial Base Length: S - N

5) Posterior Cranial Base Length: S - Ar

6) Ramus Height: Ar - Go

7) Mandibular Body Length: Go - Gn

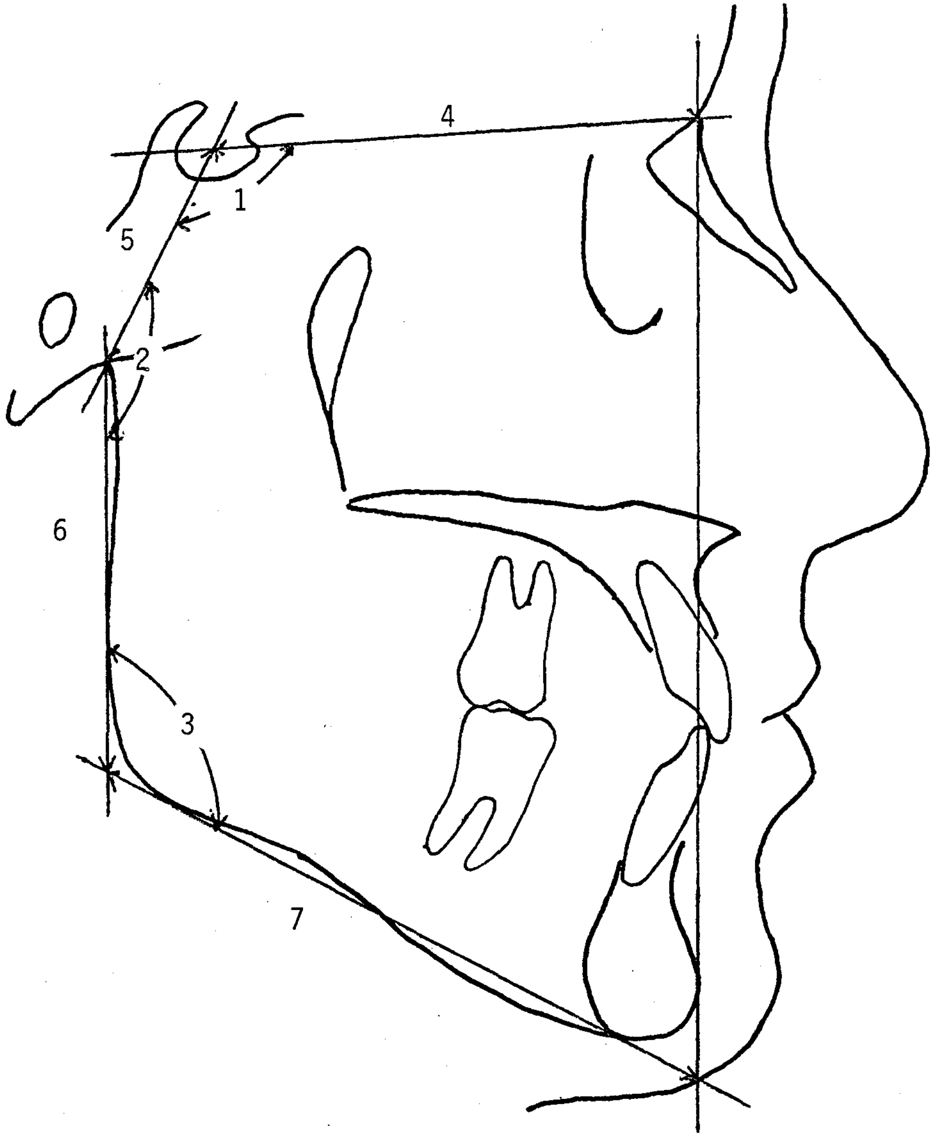


Fig. M-6

BJÖRK ANALYSIS

1) Saddle Angle
2) Articular Angle
3) Gonial Angle
4) Anterior Cranial Base Length
5) Posterior Cranial Base Length
6) Ramus Height
7) Mandibular Body Length

FROM JARABAK (Fig. M-7):

1) Anterior Facial Height: N - Gn

2) Posterior Facial Height: S - Go

3) Upper Half Gonial Angle: Ar - Go - N

4) Lower Half Gonial Angle: N - Go - Me

With these measurements, the following comparisons were made:

1) Japanese males VS. Japanese females

2) Japanese VS. Caucasians

3) Norms of this study VS. Japanese norms (of other studies).

STATISTICS

As previously described on pp. 68-80, the listed measurements were collected from each tracing and the means and standard deviations were calculated. Those means were used for comparison.

The "t" test was used to determine the statistical significance when the comparison were made between Japanese males and Japanese females and Caucasians.

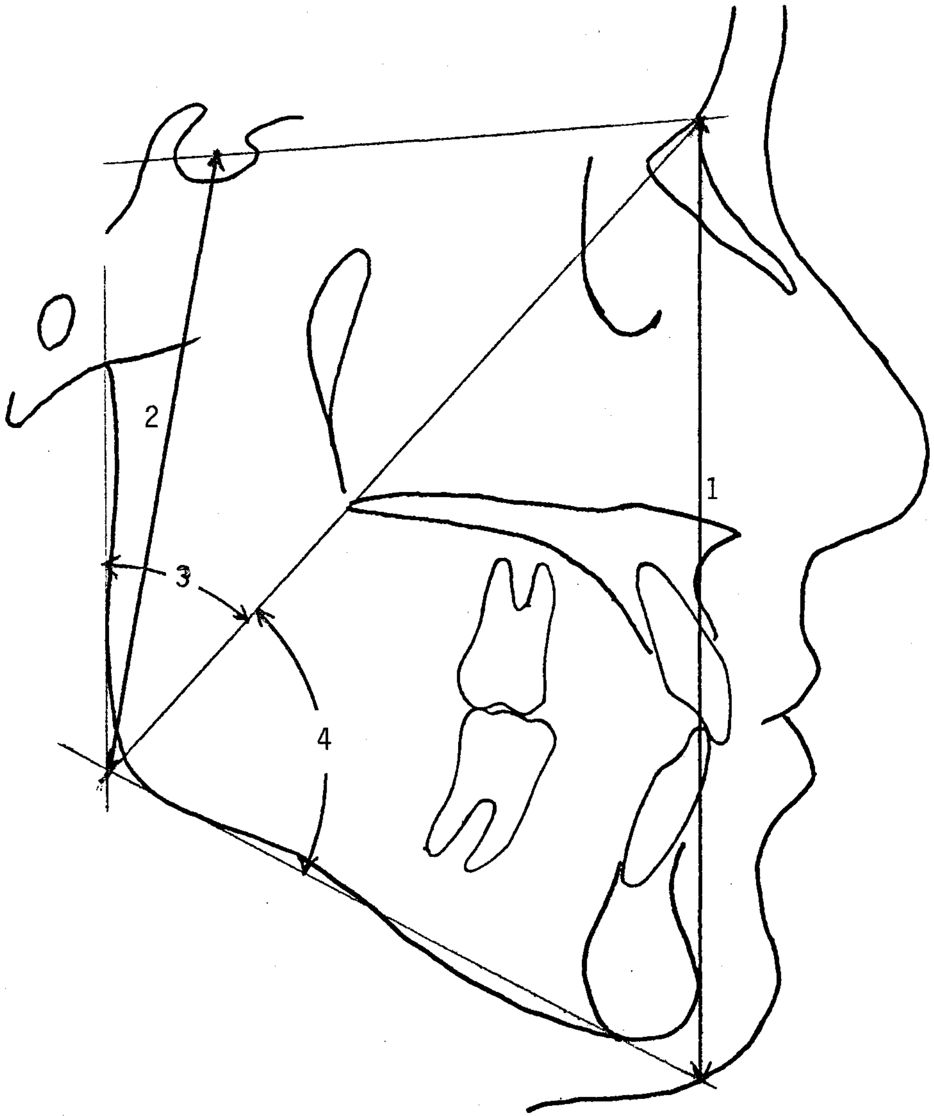


Fig. M-7

JARABAK ANALYSIS

1) Anterior Facial Height

2) Posterior Facial Height

3) Upper Half Gonial Angle

4) Lower Half Gonial Angle

CHAPTER IV.

RESULTS

A. JAPANESE MALE VS. JAPANESE FEMALE

The means and the standard deviations of the measurements are shown in Table R-1 to Table R-5. There are no significant difference between Japanese males and Japanese females in the angular measurements except:

1) Go-Gn-S-N (Steiner) ($P < .02$)

2) Facial Taper (Ricketts) ($P < .02$)

3) Sum of the Saddle angle, Articular angle and Gonial angle (Bjork). ($P < .05$)

1) and 2) both related to mandibular plane.

While Go-Gn-S-N and the sum of the measurements of the female are greater, the male converse is true for males for facial taper.

There are no significant differences between Japanese males and Japanese females in linear measurements except:

1) Porion Location (Ricketts) ($P < .01$)

2) Posterior Facial Height (Ricketts) ($P < .01$)

3) Anterior Cranial Base Length (Björk) ($P < .01$)

4) Ramus height (Björk) ($P < .01$)

5) Mandibular Body Length (Björk) ($P < .01$)

6) Anterior Facial Height (Jarabak) ($P < .01$)

7) Posterior Facial Height (Jarabak) ($P < .01$)

In all of these measurements, male is larger than female.

All of these measurements relate to the skeletal pattern.

TABLE R-1

DOWNS ANALYSIS

	Male		Female			
	Mean	S.D.	Mean	S.D.	t value	
Facial Plane Angle	85.87	3.95	86.10	3.83	0.2070	N.S.
Angle of Convexity	5.65	6.00	5.25	6.05	0.2302	N.S.
Frankfort Mand. Plane Angle	26.68	5.97	29.45	3.59	1.8580	N.S.
Y axis	64.48	4.37	63.95	3.26	0.4659	N.S.
Interincisal Angle	122.25	10.91	124.30	12.10	0.6230	N.S.
T to Mandibibular Plane Angle	96.35	9.11	93.43	8.30	1.1517	N.S.
1 to APo	6.10	3.10	5.85	3.11	0.9043	N.S.

N.S. - Not Significant
0.05 > P - Significant at or beyond the five percent level
0.02 > P - Significant at or beyond the two percent level
0.01 > P - Significant at or beyond the one percent level

TABLE R-2

STEINER ANALYSIS

	Male		Female			
	Mean	S.D	Mean	S.D.	t value	
S-N-A	81.38	3.66	80.53	3.52	0.8253	N.S.
S-N-B	78.28	3.77	77.43	4.37	0.7402	N.S.
A-N-B	3.10	3.05	3.10	2.61	0.0261	N.S.
$\underline{1}$ to N-A (mm)	8.70	3.22	7.95	3.21	0.8088	N.S.
$\underline{1}$ to N-A (degree)	25.65	9.03	23.85	8.37	0.7108	N.S.
$\overline{1}$ to N-B (mm)	9.52	3.11	8.75	2.76	0.8931	N.S.
$\overline{1}$ to NB (degree)	29.37	6.99	28.60	6.95	0.3810	N.S.
Po to N-B	1.68	1.32	1.40	1.23	0.7625	N.S.
Occlusal Plane to S-N	15.25	4.22	17.73	3.48	0.2302	N.S.
GoGn-S-N	33.55	6.02	37.63	4.66	2.5555	0.02>P

TABLE R-3A

RICKETTS ANALYSIS

	Male		Female			
	Mean	S.D.	Mean	S.D.	t value	
Interincisal Angle	122.25	10.91	124.30	12.10	0.6230	N.S.
Convexity	2.67	3.90	2.80	3.07	0.1285	N.S.
Upper Molar Position	19.95	3.65	18.48	3.19	1.4694	N.S.
Mandibular Incisor Protrusion	6.10	3.10	5.85	3.11	0.2791	N.S.
Maxillary Incisor Protrusion	9.82	3.05	9.03	3.30	0.9043	N.S.
Mandibular Incisor Inclination	28.65	5.92	26.83	5.78	1.0777	N.S.
Maxillary Incisor Inclination	29.33	6.57	28.83	7.01	0.2061	N.S.
Facial Depth	85.87	3.95	86.10	3.83	0.2070	N.S.
Facial Taper	67.35	4.22	64.48	3.95	2.4195	0.02>P
Maxillary Depth	88.42	3.17	88.65	3.69	-0.2385	N.S.
Maxillary Height	61.62	2.94	62.55	2.33	-0.1192	N.S.

TABLE R-3B

RICKETTS ANALYSIS (cont'd.)

	Male		Female			
	Mean	S.D.	Mean	S.D.	t value	
Palatal Plane Angle	-2.07	2.82	-1.78	2.69	-0.3651	N.S.
Cranial Deflection	27.45	2.24	28.48	2.09	-1.6259	N.S.
Porion Location	44.27	3.14	39.15	3.95	5.0884	0.01>P
Posterior Facial Height	76.52	5.45	67.03	4.00	6.6756	0.01>P

TABLE R-4

BJÖRK ANALYSIS

	Male		Female			
	Mean	S.D.	Mean	S.D.	t value	
Saddle Angle	125.27	4.70	124.45	5.77	0.5492	N.S.
Articular Angle	147.17	7.37	149.25	8.46	-0.9226	N.S.
Gonial Angle	121.13	7.36	122.90	5.39	-0.9204	N.S.
Anterior Cranial Base Length	74.37	3.50	69.33	3.39	5.0500	0.01>P
Posterior Cranial Base Length	41.70	3.59	35.95	2.90	5.9760	0.01>P
Ramus Height	56.0	4.56	49.15	3.50	5.6823	0.01>P
Mandibular Body Length	88.92	5.25	82.68	5.30	4.1034	0.01>P

TABLE R-5

JARABAK ANALYSIS

	Male		Female			
	Mean	S.D.	Mean	S.D.	t value	
Anterior Facial Height	141.38	5.40	132.28	5.31	5.9492	0.01>P
Posterior Facial Height	93.92	5.17	82.28	4.22	8.3757	0.01>P
Upper Half Gonial Angle	45.90	4.14	45.45	4.10	0.3782	N.S.
Lower Half Gonial Angle	75.57	5.16	77.40	3.41	-1.3955	N.S.
Sum of the Angle	393.50	5.40	396.60	4.38	-2.1390	0.05>P

B. JAPANESE VS. CAUCASIAN

The comparison was made between the results of this study and the results of previous studies (Downs[3], Alabama[41], Michigan[43], Steiner[5], ROCKY MOUNTAIN DATA SYSTEM MANUAL and Björk[2]). The results were seen on Table R-7 to Table R-10.

1) DOWNS ANALYSIS

When compared with Downs[3] original measurements (both dental pattern and skeletal pattern), all measurements in this study show a significant difference at the one percent level or less, except for the facial angle. However, the Alabama study[41] and Michigan study[43] did not show as great a difference when compared to this study. The significant differences were seen in:

1) Y axis, between the Alabama study and this study, both male and female ($P < .01$)
2) Y axis, between the Michigan female study and this female study ($P < .01$)
3) Facial angle, between the Michigan male study and this male study ($P < .02$)
4) Frankfort-mandibular plane angle between the Michigan female study and this female study ($P < .05$) (Table R7-A, R7-B)

2) STEINER ANALYSIS

Using the Steiner analysis, this study when compared to those of Steiner's5, Alabama and Michigan, significant differences were seen in:

1) $\underline{1}$ to NA (mm.) between the Steiner study and this study both mmale and female (P<.01)
2) $\underline{1}$ to NA (mm.) between the Michigan study and this study both male and female (P<.01)
3) $\underline{1}$ to NA (degree) between the Steiner study and this male study (P<.05)
4) 1 to NB (mm.) between this study and all three other studies both male and female (P<.01)
5) 1 to NB (degree) between the Steiner's and this study both male and female (P<.01)
6) Interincisal angle between Steiner's and this study both male (P<.01) and female (P<.05)
7) Occlusal plane to S-N between the Alabama study and this study, male only (P<.05)
8) Occlusal plane to S-N, between the Michigan study and this study in both male and female (P<.01)
9) Go-Gn-S-N between this female study and the three other studies (P<.01)

   (Table R-8)

3) RICKETTS ANALYSIS

When applying the Ricketts analysis the measured means from this study for both male and femmale were used as an individual Japanese male and an individual Japanese female. Because the numbers of the Ricketts norms of Table R-9 were the calculated numbers that were based on a 8.5 year old with computed yearly changes, it is not useful to make a "t" test. Instead of doing a "t" test, Table R-9A, R-9B shows the difference of the mean of this study and Ricketts clinical norms (the calculated norms based on 8.5 years old and computed yearly change) by dividing the difference between this study and Ricketts norms with Ricketts clinical deviation (used as a standard deviation in Ricketts analysis). For example, the interincisal angle Ricketts male 130.0, Mitani male 122.25, and Ricketts clinical deviation of 6.0 yields: $\frac{130.0-122.3}{6.0} = 1.21.$

This means Mitani male was 1.2 clinical deviation off the Ricketts norm, thus the interincisal angle shows a difference between Ricketts male and Mitani male of over 1 C.D.

The differences a seen on Table R-9 were as follows:

1) Interincisal angle, Mitani's male over -1 C.D. from Ricketts male.
2) Convexity, Mitani's male over +1 C.D. from Ricketts male.

3. Mandibular incisor protrusion, both Mitani male and female over +2 C.D. from Ricketts male and female.

4) Maxillary incisor protrusion, Mitani male (over +3 C.D.) and female (over +2 C.D.) from Ricketts male and female.

5) Mandibular incisor inclination, both Mitani male and female over +1 C.D. from Ricketts male and female.

6) Facial depth Mitani male over -1 C.D. from Ricketts male.

7) Facial taper: Mitani female over -1 C.D. from Ricketts female.

8) Maxillary height: Mitani male over +1 C.D. female over +2 C.D. from the Ricketts male and female.

9) Posterior facial height, Mitani male over +3 C.D. female +2 C.D. from the Ricketts male and female.

(Table R-9A, R-9B)

4) BJÖRK ANALYSIS

The standard orientation of the cephalostat that Björk used was 155 cm from the anode to the median plane and 90 mm. from the median plane to the film surface. This orientation of the machine makes a different enlargement ratio from the Japanese standard orientation. (See Chapter III). Because of this, a "t" test between this study and the Björk study is not useful. The results are shown on Table R-10.

TABLE R-6A

THE SAMPLE CHARACTERISTICS OF THE STUDIES:

AMERICAN (CAUCASIANS) STUDIES

	DOWNS (1948)	ALABAMA ANALYSIS (1966)	MICHIGAN (1974)	STEINER (1953)	BJÖRK (1948)	
Male numbers	10	17	47	Unknown	322	281
age	12-17	8-15	6-16		12-13	21-23
Female numbers	10	23	36	Unknown	No Females	
age	12-17	8-15	6-16			
Condition of samples	normal occlusion	normal occlusion condition-1	normal occlusion condition-2	Unknown	good occlusion condition-3	

1 - Untreated orthodontically, pleasing or at least acceptable facial development. Families were of predominantly Southern extraction for at least two generations.

2 - Except, continuous attendance at the University School over the period ranging from 6-16 years.

3 - Not more than a single permanent tooth decayed, not more than a single missing tooth, and no Orthodontic treatment.

TABLE R-7A

DOWNS ANALYSIS (MEANS AND STANDARD DEVIATIONS)

	DOWNS	ALABAMA	MICHIGAN		MITANI	
			Male	Female	Male	Female
FACIAL ANGLE	87.8*	87.7	82.5**	86.0	85.87	86.10
	3.57	3.3	3.9	2.5	3.95	3.83
			N=13	N=5		
ANGLE OF CONVEXITY			4.4	3.2	5.65	5.25
	-0-***	4.0	6.0	5.6	5.99	6.05
	5.09+++	5.1	23	9		
AB PLANE ANGLE			-6.0	-4.9		
	-4.6		3.1	3.5		
	3.67		23	9		
FRANKFORT	21.9***	26.4	28.7	25.8+	26.68	29.45
MANDIBULAR	3.27+++	4.6++	5.2	3.0	5.97	3.59
PLANE ANGLE			13	5		
Y AXIS	59.4***	60.4***	63.5	59.6+++	64.48	63.95
	3.82+++	3.5+++	3.8	2.6	4.37	3.26
			13	5		

* .05 > P > .02 (Male)	+ .05 > P > .02 (Female)
** .02 > P > .01 (Male)	++ .02 > P > .01 (Female)
*** P < .01 (Male)	+++ P < .01 (Female)

Significant "T" comparison with Mitani study

TABLE R-7B

DOWNS ANALYSIS (cont'd.)

	DOWNS	ALABAMA	MICHIGAN		MITANI	
			Male	Female	Male	Female
CANT OF OCCLUSAL PLANE	9.3 3.83		9.7 3.5 13	8.3 1.5 5		
INTER INCISAL ANGLE	135.4*** 5.76+++	126.8 8.4	126.6 10.0 23	133.6 13.0 9	122.25 10.91	124.30 12.10
$\overline{1}$ to MANDIBULAR PLANE	1.4*** 3.78+++	97.3 6.3	95.6 6.6 23	92.8 9.4 9	96.35 9.11	93.43 8.47
1 to OCCLUSAL PLANE	14.5 3.48		25.3 6.8 23	18.9 10.1 9		
DISTANCE $\underline{1}$ to A-Po	2.7*** 3.05+++	5.9 2.0	7.4 2.7 23	5.2 3.2 9	6.10 3.10	5.87 3.11

TABLE R-8

STEINER ANALYSIS

	STEINER	ALABAMA	MICHIGAN Male	MICHIGAN Female	MITANI Male	MITANI Female
S-N-A	82	81.0 3.2	81.4 4.4	81.8 3.7	81.38 3.66	80.53 3.52
S-N-B	80	78.2 2.9	78.2 3.9	79.2 2.3	78.28 3.77	77.43 4.37
A-N-B	2	2.8 2.0	3.2 2.3	2.6 2.4	3.10 3.05	3.10 2.66
S-N-D	76					
1 to NA (mm.)	4*** +++		5.5*** 2.7	3.8 2.7+++	8.70 3.22	7.95 3.21
1 to NA (degree)	22*	23.2 5.0	23.8 6.1	21.4 6.9	25.65 9.03	23.85 8.37
1 to NB (mm.)	4*** +++	5.4*** 1.5+++	6.1*** 2.9	3.4 3.6+++	9.52 3.11	8.75 2.76
1 to NB (degree)	25*** +++	27.3 5.8	26.4 7.3	22.4 9.6	27.47 6.19	28.60 6.96
Po to NB (mm.)	?		2.4 2.5	2.1 1.6	1.68 1.32	1.40 1.23
INTERINCISAL ANGLE	131*** +	126.8 8.4	126.6 10.0	133.6 13.0	122.25 10.91	124.30 12.10
OCCLUSAL PLANE to S-N	14	16.7* 4.1	12.91*** 4.1	14.4 2.5+++	15.25	17.73
GoGn-SN	32+++	32.0 4.5+++	32.6 5.2	31.3 3.1+++	33.55 6.02	37.63 4.66

RICKETTS ANALYSIS

	RICKETTS CAUCASIAN		RICKETTS JAPANESE		MITANI	
	Male	Female	Male	Female	Male	Female
INTERINCISAL ANGLE	130.0 .	130.0	125.0	125.0	122.25	124.30
	6.0	6.0	6.0	6.0	10.91	12.10
CONVEXITY	0.3 .	0.8	2.5	3.1	2.67	2.80
	2.0	2.0	2.0	2.0	3.90	3.07
UPPER MOLAR POSITION	20.0	17.0	20.0	17.5	19.95	18.48
	3.0	3.0	3.0	3.0	3.65	3.19
MANDIBULAR INCISOR PROTRUSION	1.0 ..	1.0 xx	2.0 .	2.0 x	6.10	5.85
	2.3	2.3	2.3	2.3	3.10	3.11
MAXILLARY INCISOR PROTRUSION	3.5 ...	3.5 xxx	4.5 ..	4.5 x	9.82	9.03
	2.3	2.3	2.3	2.3	3.05	3.30
MANDIBULAR INCISOR INCLINATION	22.0 .	22.0 x	26.0	26.0	28.65	26.83
	4.0	4.0	4.0	4.0	5.92	5.78
MAXILLARY INCISOR INCLINATION	28.0	28.0	29.0	29.0	29.33	28.83
	4.0	4.0	4.0	4.0	6.57	7.01
FACIAL DEPTH	91.4 .	88.15	88.8	87.8	85.87	86.10
	3.0	3.0	3.0	3.0	3.95	3.83
FACIAL TAPER	68.0	68.0 x	66.0	66.0	67.35	64.48
	3.5	3.5	3.5	3.5	4.22	3.95

TABLE R-9B

RICKETTS ANALYSIS (cont'd.)

	RICKETTS CAUCASIAN		RICKETTS JAPANESE		MITANI	
	Male	Female	Male	Female	Male	Female
MANDIBULAR PLANE ANGLE	25.5 4.5	26.5 4.5	22.1 4.5	22.7 x 4.5	26.68 5.97	29.45 3.59
MAXILLARY DEPTH	90.0 3.0	90.0 3.0	90.0 3.0	90.0 3.0	88.42 3.17	89.15 3.69
MAXILLARY HEIGHT	56.4 . 3.0	55.4 xx 3.0	60.0 3.0	61.0 3.0	61.62 2.94	62.55 2.33
PALATAL PLANE ANGLE	1.0 3.5	1.0 3.5	-1.0 3.5	-1.0 3.5	-2.07 2.82	-1.78 2.69
CRANIAL DEFLECTION	27.0 3.0	27.0 3.0	28.0 3.0	28.0 3.0	27.45 2.24	28.48 2.09
POSTERIOR FACIAL HEIGHT	61.8 ... 3.33	59.2 xx 3.3	65.8 ... 3.3	64.0 3.3	76.52 5.45	67.03 4.00
PORION LOCATION	-43.0 2.2	-41.75 2.2	-41.4 . 2.2	-40.1 2.2	-44.27 3.14	-39.15 3.95

. the difference is over 1 C.D. (Male)
.. the difference is over 2 C.D. (Male)
... the difference is over 3 C.D. (Male)

x the difference is over 1 C.D. (Female)
xx the difference is over 2 C.D. (Female)
xxx the difference is over 3 C.D. (Female)

TABLE R-10

BJÖRK ANALYSIS

	BJÖRK	MITANI MAle	MITANI Female
SADDLE ANGLE	122.90 4.85	125.27 4.70	124.45 5.77
ARTICULAR ANGLE	142.96 6.21	147.17 7.37	149.25 8.46
GONIAL ANGLE	131.09 6.11	121.13 7.36	122.90 5.39
SUM		393.50 5.40	396.60 4.38
ANTERIOR CRANIAL LENGTH	73.22 3.26	74.37 3.50	69.33 3.39
POSTERIOR CRANIAL LENGTH	37.02 3.32	41.70 3.59	35.59 2.90
RAMUS HEIGHT	53.23 5.15	56.60 4.56	49.15 3.50
BODY LENGTH	80.66 5.16	78.87 4.49	73.05 4.10

C. JAPANESE VS. JAPANESE

The comparison was made between the results of this study and the results of previous Japanese studies; Kayukawa (1954)15, Iizuka and Ishikawa (1957),16 Yamauch (1964),58 Shishikura (1969),71 Matsuura (1975),82 and Uesato, Kinoshita (1978).85
The results are seen on the Tables R-9A, R-9B, R-12, R-13.

1) DOWNS ANALYSIS

Comparing this study with other Japanese studies that were done by Kayukawa (1954),15 Iizuka and Ishikawa (1957)16 and Yamauch (1964)58 using the Downs analysis, the following measurements are significantly different from this study:

1) Angle of convexity, between the Kayukawa study and this study, both male and female ($P < .05$).
2) Interincisal angle, between Iizuka, Ishikawa study's male and this study's male ($P < .01$).
3) $\underline{1}$ to A-Po, between this study (both male and female), and Iizuka, Ishikawa and Yamauch ($P < .01$); otherwise there are no significant differences between this study and other studies (Table R-12).

2) STEINER ANALYSIS

Comparing this study with other Japanese studies done by Shishikura (1969),71 Uesato, Kinoshita (1978),85 and Matsuura (1975)82 using the Steiner Analysis, the following significant differences from this study were seen:

1) S-N-A of Matsuura is significantly different from this study ($P<.05$ for females).
2) 1 to N-A of Shishikura is significantly different from this study ($P<.01$ for males).
3) 1 to N-A (mm) of Uesato, Kinoshita is significantly different ($P<.01$ for both males and females).
4) 1 to N-A (degree) of Matsuura is significantly different from this study ($P<.05$ for males).
5) 1 to N-B (mm) of Shishikura is significantly different from this study ($P<.05$ for males).
6) 1 to N-B (mm) of Uesato, Kinoshita is significantly different from this study ($P<.02$ for male and $P<.01$ for females).
7) 1 to N-B (mm) of Matsuura is significantly different from this study ($P<.02$ for males).
8) Interincisal of Matsuura is significantly different from this study ($P<.02$ for males).
9) GoGn-S-N of Shishikura is significantly different from this study ($P<.05$ for males).

10) GoGn-S-N of Uesato Kinoshita is significantly different from this study ($P<.01$ for females).

11) GoGn-S-N of Matsuura is significantly different from this study ($P<.05$ for females). (Table R-13)

3) RICKETTS ANALYSIS

When applying the Ricketts analysis, the measurements of this study, both male and female, were used as an individual Japanese male and an individual Japanese female. The numbers of Ricketts Japanese male and female are calculated numbers that were based on 12 year olds with computed yearly changes. Instead of doing a "t" test, Table R-9A, R-9B, shows the difference of the mean of this study and Ricketts Japanese clinical norms by dividing the difference between this study and Ricketts Japanese clinical norms with Ricketts Japanese clinical deviation.

Comparing this study with Ricketts' Japanese norm the following differences could be observed:

1) The mandibular incisor protrusions of this study, both male and female are, one clinical deviation from Ricketts' Japanese norms.

2) The maxillary incisor protrusion of this male study is two clinical deviations and of this female study is one clinical deviation from Ricketts' Japanese norms.

3) The mandibular plane of this male study is almost one clinical deviation and of this female study is one clinical deviation from Ricketts' Japanese norms.

4) The posterior facial height of this study male is three clinical deviations from Ricketts' Japanese norms.

5) The male porion location of this male study is one clinical deviation from Ricketts' Japanese norms. (See Table R-9A, R-9B)

TABLE R-11

THE SAMPLE CHARACTERISTICS OF THE STUDIES:

JAPANESE STUDIES

	KAYUKAWA (1955)	IIZUKA ISHIKAWA (1957)	YAMAUCH et. al. (1964)	SHISHIKURA (1969)	UESATO KINOSHITA (1978)	MATSUURA (1975)
Male						
number	23	50	31	96	25	36
age	high school student	avg. 23 yr. 7mo. 19 yr. 11 mo. to 28 yr. 11 mo.	21-28	23-27	11-18	20-25
Female						
number	9	50	38	No	25	36
age	high school student	avg. 19yr. 7mo. 18yr. 5 mo. to 27 yr. 4 mo.	18-25		11 to 18 yr.	20-25
Conditions						
	normal occlusion	normal occlusion	normal occlusion-1	normal occlusion-2	acceptable occlusion-3	good face-4

1 - No abnormality of jaws and face.

2 - Class I malocclusion.

3 - Acceptable incisor relationship, balanced profile.

4 - No abnormality, Class I and midline occlusion, no history of fixed prosthetics.

TABLE R-12

DOWNS ANALYSIS (JAPANESE STUDIES)

	KAYUKAWA (1955)	IIZUKA (1957) ISHIKAWA Male	Female	YAMAUCH (1964) Male	Female	MITANI Male	Female
FACIAL ANGLE	85.1	85.07	84.83	84.2	84.6	85.87	86.10
	3.15	5.76	3.05	3.22	3.62	3.95	3.83
CONVEXITY	8.5*	5.60	7.58	6.1	6.6	5.65	5.25
	5.15+	4.33	4.95	5.28	3.24	5.99	6.05
A-B PLANE	-5.9	5.10	-4.81	-5.1	-5.3		
ANGLE	2.99	3.28	3.50	2.66	1.99		
MANDIBULAR	28.5	26.25	28.81	26.2	28.6	26.68	29.45
PLANE ANGLE	3.93	6.34	5.23	6.02	6.20	5.97	3.59
Y AXIS	65.9	65.71	65.38	66.5	65.2	64.48	64.95
	3.85	3.27	5.63	4.22	4.73	4.37	3.26
OCCLUSAL	11.6	9.52	11.42	11.4	10.7		
PLANE	4.20	4.01	3.64	5.56	4.70		
INTERINCISAL	120.8	129.6***	124.09	125.5	125.6	122.25	125.30
ANGLE	8.10	8.99	7.63	10.62	7.44	10.91	12.10
$\overline{I}$ TO OCCLUSAL	23.8	21.69	23.84	23.1	24.0		
PLANE	5.94	6.03	5.28	6.94	4.97		
$\overline{I}$ TO MANDIBULAR	5.8	94.67	96.33	97.2	96.2	96.35	93.43
PLANE	7.39	7.21	5.78	6.34	4.75	9.11	8.47
$\underline{1}$ TO APo	6.6	7.86***	8.92	8.9***	8.5	6.10	5.87
	2.15	2.31	1.88+++	3.04	1.66+++	3.10	3.11

TABLE R-13

STEINER ANALYSIS (JAPANESE STUDIES)

	SHISHIKURA (1969)	UESATO KINOSHITA (1978)	MASUURA (1975)	MITANI Male	Female
S-N-A	81.5 3.5	80	82.08 2.66+	81.38 3.66	80.53 3.52
S-N-B	77.6 3.7	77	78.55 2.75	78.28 3.77	77.43 4.37
S-N-D	75.3 3.7	75			
$\underline{1}$ to N-A (mm)	5.4*** 2.2	4*** +++		8.70 3.22	7.95 3.21
$\underline{1}$ TO N-A (degree)	22.1 7.0	23	21.97* 6.55	25.65 9.03	23.85 8.37
$\overline{1}$ TO N-B (mm)	7.4*** 2.4	5** +++	7.99** 2.55	9.52 3.11	8.75 2.76
$\overline{1}$ TO N-B (degree)	29.5 5.5	26	28.83 4.10	29.37 6.99	28.60 6.96
Po TO N-B	1.9 1.5			1.68 1.32	1.40 1.23
INTERINCISAL ANGLE	124.7 8.8	128	125.81* 4.94	122.25 10.91	124.30 12.10
OCCLUSAL TO S-N	15.1 4.8	18	17.29 3.37	15.25	17.75
Go-Gn-S-N	30.4* 6.13	34+++	34.84 4.74	33.55 6.02	37.63 4.66

CHAPTER V.

DISCUSSION

A. JAPANESE MALE VS. JAPANESE FEMALE:

The significant difference of the angular measurements can be seen on Go-Gn-S-N, Facial Taper, and the sum of the saddle angle, articular angle and gonial angle. These measurements relate to the mandibular plane (Menton to the lower border of the mandible).

These numbers show that the Japanese male has a smaller mandibular plane angle than the Japanese female. Fig. D-1 shows the triangle of the Frankfort plane, facial plane, and mandibular plane of the male and the female. Above the triangle is the S-N plane. These figures show that the Japanese male and the Japanese female have the same relationship between the Frankfort plane and the facial plane, but not the mandibular plane. This fact indicates the female possibly has a shorter posterior facial height than the male.

Fig. D-2 shows the modified Bjork diagrams. These diagrams were constructed using the anterior cranial base length, the posterior cranial base length, the ramus height, the mandibular body length and the corresponding angles, the saddle angle, the articular angle and the gonial angle from Bjork. The anterior facial height and posterior facial height were taken from Jarabak and the porion location and the posterior facial height from Ricketts. These linear measurements show significant differences between the Japanese male and the Japanese female indicating that the male is larger than female in size in all of the above linear measurements.

Fig. D-3 shows the percentage of each corresponding measurement of female to male as seen in Fig. D-2. (For example the anterior face height of the Japanese female, 132.18, divided by Japanese male, 141.38, gave the percentage of 92.9).

Comparing the Japanese male and the Japanese female, the percentage of the anterior cranial base length, the mandibular body length and the anterior face height of the Japanese female are about 93% of the Japanese male. However, the posterior cranial base length, the ramus height, Jarabak posterior facial height (S-Go), Ricketts posterior facial height (CF-Go) and the porion location of the female are about 86% to 87% of the male.

This fact indicates that the sex difference between the Japanese male and the Japanese female structures of the face is more significant in the posterior structure than in the anterior structures. The modified Bjork diagram shows the diagram of the male is not evenly expanded over the female diagram. The Japanese male is different from the Japanes female not only by the absolute size, but also by the uneven ratio of the anterior facial structures to the posterior facial structures.

These differences between anterior and posterior structures may create the difference of the male gonial angle and female gonial angle, and it may make the female mandibular plane more steep than the male; also it may form a larger S-N-Go-Gn for the female and a smaller taper for the female.

The difference between male structures and female structures may be explained by the differential growth of the posterior cranial base and late growth of the condyle.

In the Japanese studies, Sakamoto[51] reported the Japanese general growth pattern (1959). Sakamoto used cross-sectional data and divided the samples into age groups from I to V for both male and females. He also used the Cartesian Coordinate system with the X axis parallel to the Frankfort horizontal plane and the intersection of the X axis and Y axis on sella tursica. Sakamoto did not discuss the large changes of the gonion and the mandibular plane between the male group IV (age twelve years eleven months) and the male group V (age twenty-three years seven months). At that period the gonion in male changes from -76.81 to -90.45 vertically and from -13.77 tro -15.12 horizontally in actual linear measurements, while in females, the gonion changes from -75.01 to -80.74 vertically and from -12.21 to -13.11 horizontally. Sakamoto also showed the vertical and horizontal growth rates, considering group V as 100%. The growth rates of the male gonion group IV (age twelve years eleven months) was 84.92% in vertical and 91.07% in horizontal while the females in group IV (age twelve years eleven months) was 92.90% in vertical and 93.14% in horizontal of the female group V (age nineteen years seven months). This vertical change of the male gonion make the male mandibular plane more parallel to the Frankfort horizontal than the female. This change may indicate the late growth of the condyle. Because of the difference of the methods, it is not possible to make a direct comparison with the study of this thesis, however the results of Sakamoto point in the same direction as this study.

Brodie[33] also stated this change in his article (1953). In this study, Brodie used nineteen white males ages eight to seventeen years. His statements are as follows: "The mandibular (lower) border, similarly shows no appreciable change in over half of the cases. In those cases where it does change it almost invariable shows a behavior similar to that of the occlusal plane, that is, a tendency to become more parallel with the anterior cranial base."

Knott, V.B.,[86,87] discussed the changes in the cranial base measurements in humans (1971). In this article Knott summarized his findings "Findings on the male to age fifteen years differ from those for females in that between age twelve and fifteen males show greater increase in frontal (frontal to frontal sinus point) and postsphenoid (pituitary point to anterior point on occipital condyles) segments of the cranial base. Extension of analysis into early adulthood revealed sex differences in adult size of the frontal presphenoid and postsphenoid segments. For the frontal and presphenoid segments, changes were greater for male than female after age fifteen years."

The sexual dimophism in Caucasian is expressed in detail in the Ricketts Cephalometric analysis. Ricketts uses the same measurement (angular and linear) for males and females up to until puberty for females and then increments in certain linear and angular measurements for the males up to their growth cessation age. The following measurements are found to change according to Ricketts; 1) Convexity, 2) Upper Molar Position, 3) Occlusal Plane to Ramus, 4) Occlusal Plane Inclination, 5) Lip Protrusion, 6) Facial Depth, 7) Mandibular Plane Angle, 8) Cranial Length, 9) Porion Location, 10) Mandibular Arc. Of those measurements made on Japanese males and females, results are roughly similar to Caucasian male and female differences in similar age ranges.

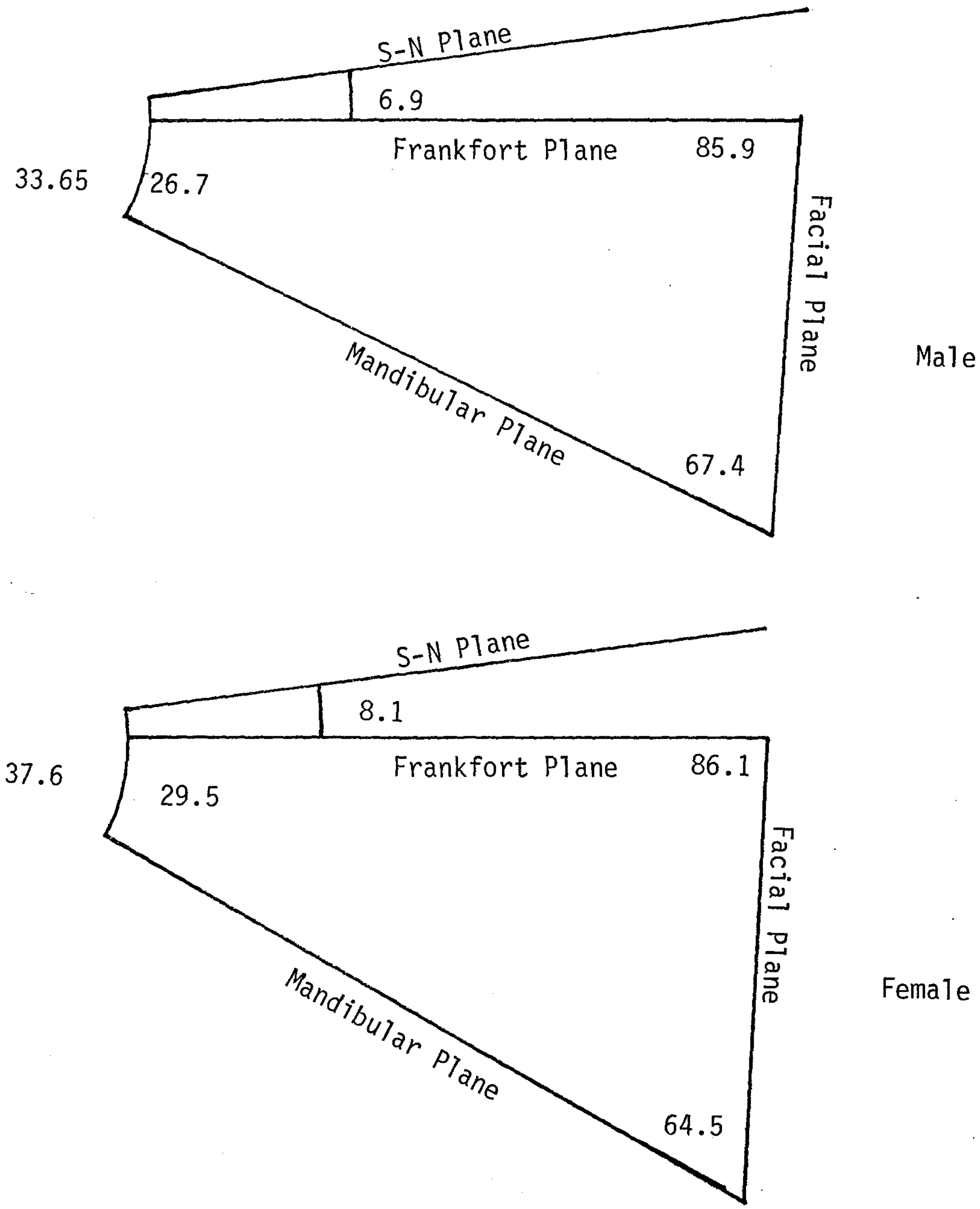


Fig. D-1 Tweed Triangle of Japanese males and Japanese females

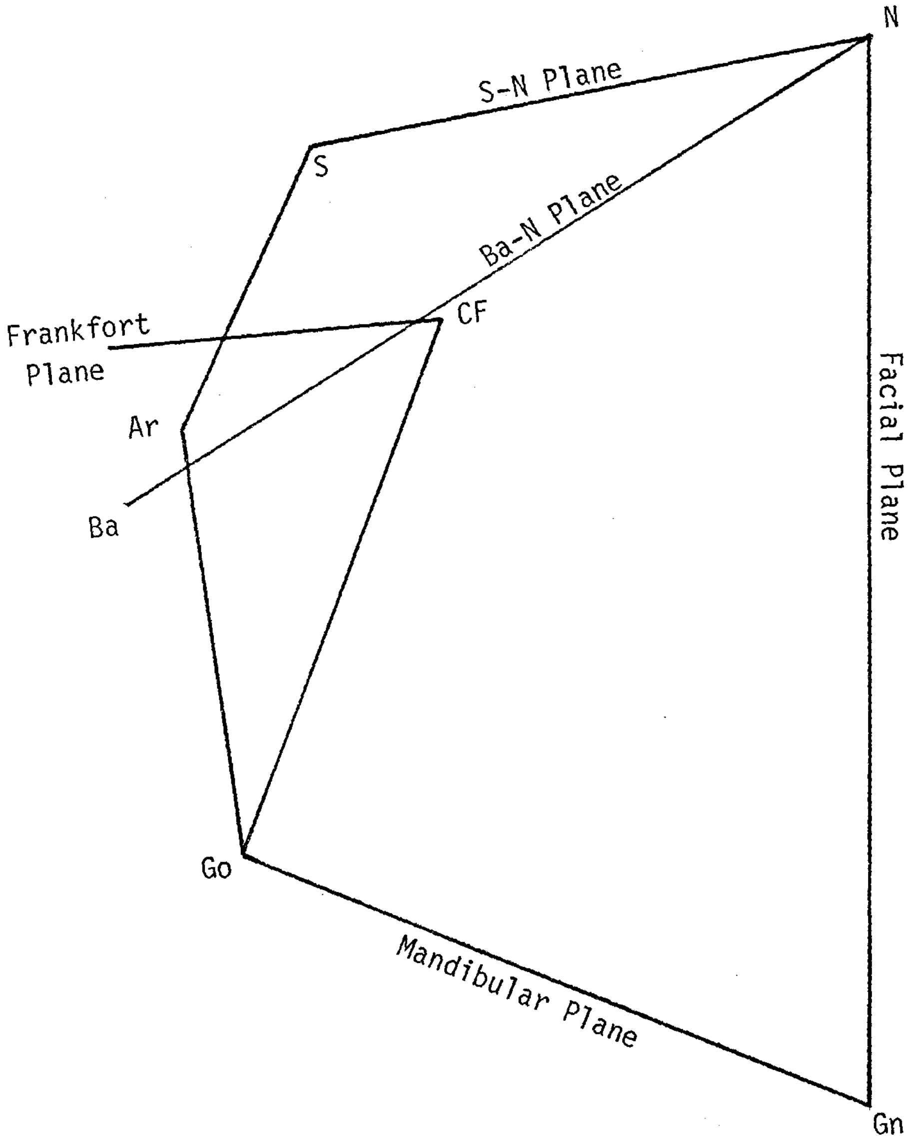


Fig. D-2A Modified Björk Diagram of the Average Japanese Male

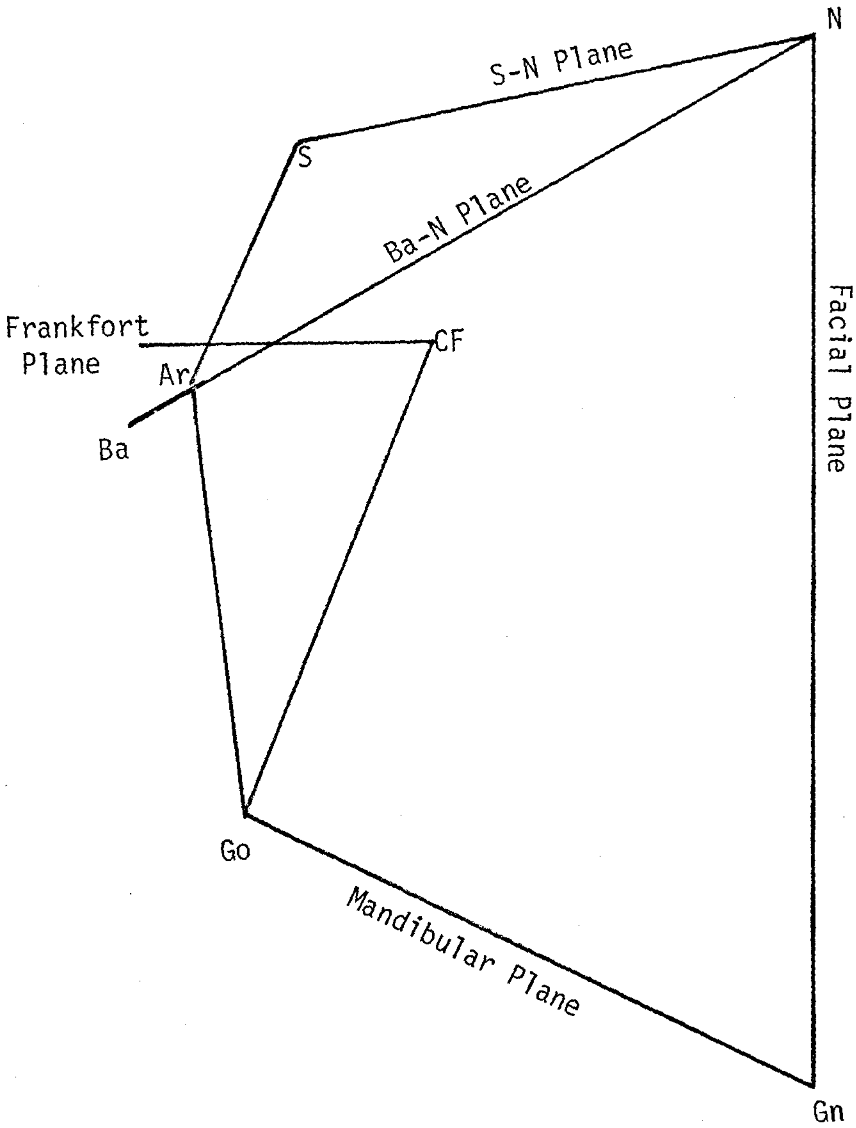


Fig. D-2B Modified Björk Diagram of the Average Japanese Female

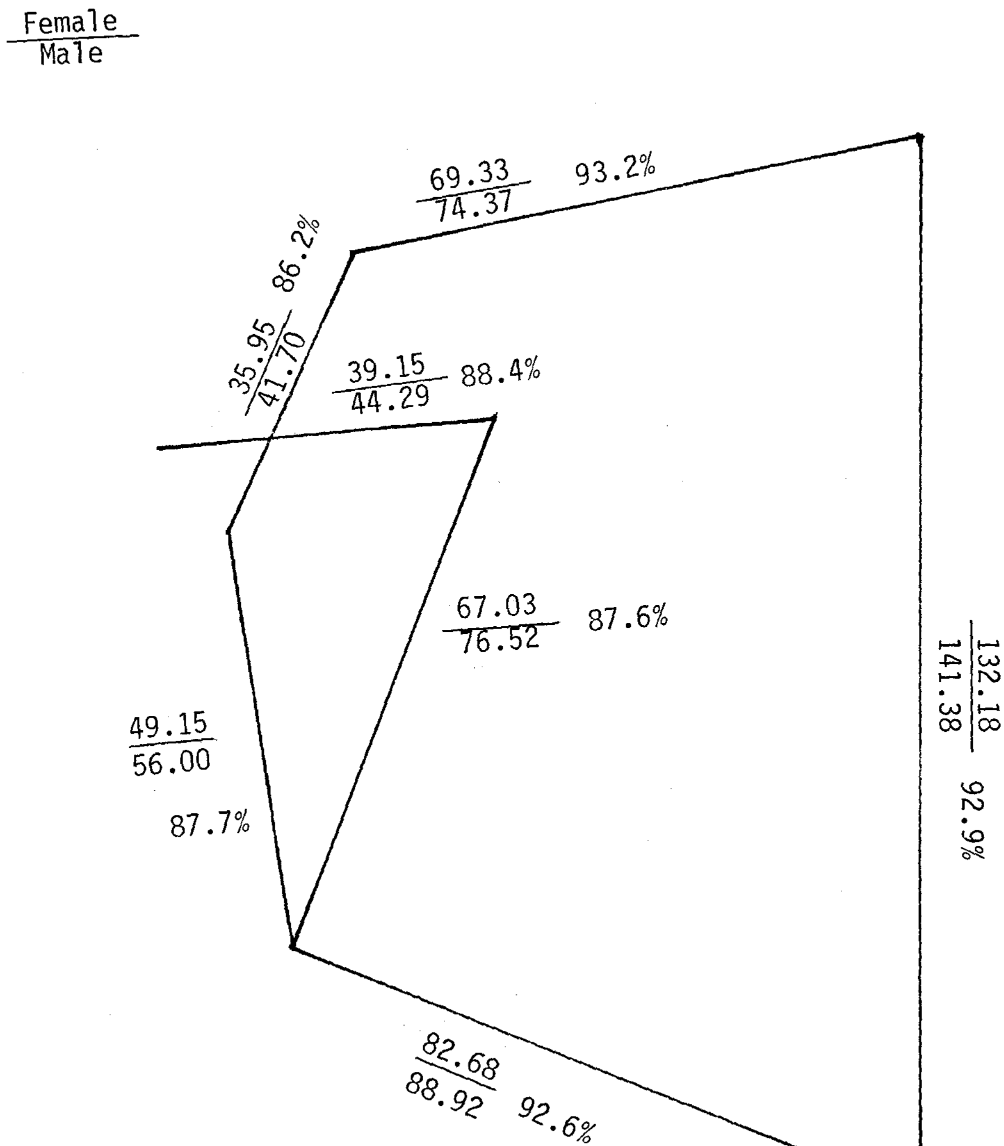


Fig. D-3 Comparison of the Modified Björk Diagram of Japanese Males and Japanese Females

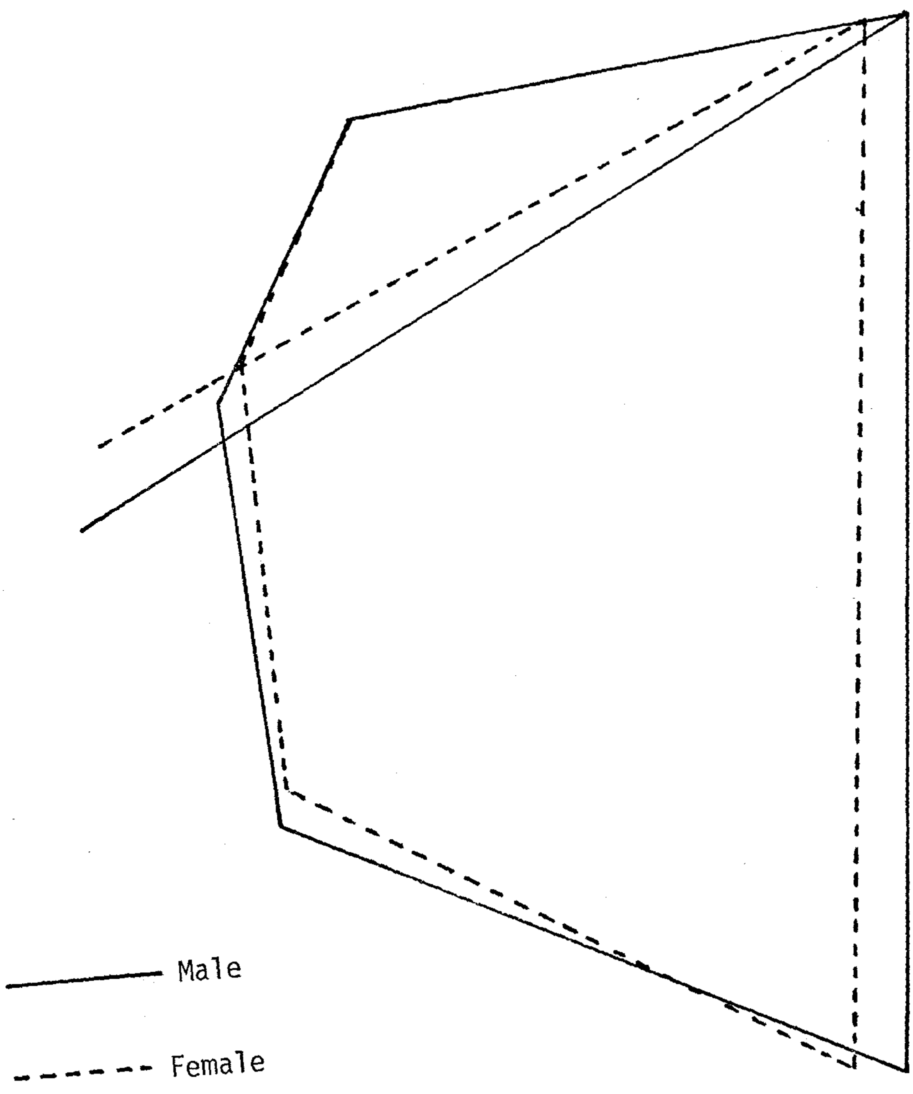


Fig. D-4 Superimporsition of Modified Björk Diagrams of Japanese males and females

B. JAPANESE VS. CAUCASIAN:

1) DOWNS ANALYSIS

The Downs measurements are significantly different from the results of this study at the one percent level or less, excluding the facial angle. However, the Alabama study[41] and Michigan study[43] did not show as large difference as Downs study when compared to this study.

Considering the Caucasian norms, the Downs norm is very different from the other two studies. It is not the purpose of this thesis to discuss the difference between Caucasian norms, but it can be said that the Downs norm shows a more straight profile and square mandible comparing the Alabama study and the Michigan study. Even in the same race sometimes the differences between the Caucasian norms are larger than the difference between the Caucasian norms and Japanese norms.

The common difference between the Japanese (this study) and the three Caucasian norms is the Y axis. Although the Michigan male study does not show this significant difference, the others show significant difference from Japanese in the Y axis.

Downs himself stated, one angle or one measurement should not be discussed individually. But this difference of the Y axis may indicate the Japanese horizontal components of the face are shorter than the Caucasian, or the Japanese vertical components of the face are larger than the Caucasian, or a combination of both. Although not significantly different, the Japanese show a larger angle of convexity and slightly smaller interincisal angle. It can not be said that the Japanese have a more convex profile as the older Japanese studies indicated. It can be said the Japanese have more Class II tendency, both in denture and skeletal pattern, and a more protrusive profile, based on the Downs standard. Similarly the Alabama and the Michigan norms clearly show a Caucasian Class II tendency from the view point of the Downs standard. These two studies are closer to the Japanese than the Downs norm.

This may be due to the difference in the experimental sampling. The time of the sampling (years in which the studies were done) may affect the results in that people's ideas of esthetics and what composes a pleasing facial appearance have changed, as exemplified by the change from a straight profile to a slightly fuller convex profile. The bias of the sampler must affect the result. Also the difference between a true norm VS an idealized sample affects the result.

Baum (1951)[26] showed the difference of the sampling in his study using Downs analysis. In that study the differences between Downs norms and Baum's results were clearly seen. Baum thought the differences between his study and the Downs study were based on the age difference. But Downs norms showed a straight type facial pattern and

Baum's results showed Class II facial pattern or convex facial pattern. It could not be possible to change a Class II facial pattern to a striaght facial pattern in two years, even "the adults have a straighter face than children" as Ricketts said.

2) STEINER ANALYSIS

When comparing the results of this study to the Steiner analysis with Steiner's[5] original study, the Alabama study and the Michigan study, there were no significant differences between Steiner's original study, the Alabama study, Michigan study and this study on S-N-A, S-N-B, and A-N-B difference. Otherwise the Steiner study shows significant differences on $\underline{1}$ to N-A, (both mm. and degree), $\overline{1}$ to N-B (both mm. and degree) and the interincisal angle on both male and female and Go-Gn-SN on the female. The Alabama study shows significant differences on 1 to N-B (mm.) both male and female, occlusal plane to S-N with male and Go-Gn-S-N with female. The Michigan study shows significant differences on $\underline{1}$ to N-A (mm.), $\overline{1}$ to N-B (mm.) and occlusal plane to S-N both male and female, and on Go-Gn-S-N on female. (See table R-8).

On the table R-8, generally speaking, there are not many differences between Japanese and Caucasians on the jaw relationships. But because Japanese incisors are more labially tipped and positioned anteriorly, $\underline{1}$ to N-A (mm.), the Japanese show a larger $\overline{1}$ to N-B (mm.), and smaller interincisal angles. The Japanese also show a slightly tilted occlusal plane and larger Go-Gn-S-N angle.

According to these facts, Japanese have slightly smaller S-N-A and S-N-B and slightly larger A-N-B difference but there are no significant differences between Japanese and Caucasians. However, Japanese central incisors are more protrusive and at the same time, they are more tilting buccally than Caucasians.

3) RICKETTS ANALYSIS

Compared with this study, Ricketts Caucasian norms show a larger interincisal angle (both male and female) slightly smaller convexity (both male and female) much smaller mandibular incisor protrusion and maxillary incisor protrusion (both male and female), slightly smaller mandibular incisor inclination, larger facial taper (female) larger facial depth (male) and smaller maxillary height (both male and female). The palatal plane angle of the Ricketts norms are slightly smaller than this study.

According to these facts, it can be said; 1) in the antero-posterior relationship, there are little differences between Japanese and Caucasians because the upper molar position and the porion location show similar values, 2) in the vertical, Japanese may be larger than Caucasians because the maxillary height, the posterior facial height and the mandibular plane angle, and palatal plane angle of the Japanese are larger than Caucasians, 3) in the profile, the Japanese present a more retrusive face than Caucasians because the maxillary depth and the facial depth of Japanese are smaller than Caucasians, even Japanese convexity is larger, 4) in the dental to the skeletal relationship Japanese have a more protrusive denture than Caucasians because the maxillary and mandibular incisor protrusion of the Japanese are much larger than Caucasians.

4) BJÖRK ANALYSIS

The standard of orientation of the cephalostat that Bjork used was 155 cm. from the anode to the median plane and 90 mm. from the median plane to the film surface. This orientation of the machine that Bjork used made about a six percent enlargement of the picture in the medial plane, but the Japanese standard of studies made a ten percent enlargement resulting from the standard orientation. Due to this, a comparison of the linear measurements could not be made directly but angular measurements could be compared with each other without correction.

The Björk study shows a smaller saddle angle (both male and female), a smaller articular angle (both male and female) and a larger gonial angle (both male and female) than the Japanese. When superimposed on the S-N plane at S, these facts make it appear that the Japanese have a lower and more retroposition of the mandible than Caucasians. (Table R-10)

Comparing the Caucasian studies and the Japanese studies, the Japanese studies show less variation than the Caucasian studies. These variations may be due to the difference in sampling. The age and sex must be large factors. The age of the sample has special meanings. If the samples were not taken from the same age range, sometimes they don't have useful mean values. The sex differences are the same as the age differences. Before the age of the puberty there are no sex differences but once they reach puberty the sex differences are seen and it is not wise to mix the male samples and female samples.

Another factor in sample selection is the "Ideal" normals. Some of the studies were done by using "Ideal" normal samples. Usually this "Ideal" meant how the person or people who were doing the research thought a face of a human being should look like and the "Ideal" have no relation to an average face or population norm.

Another factor is the place of the sampling. Some study samples were selected out of orthodontic practices. Without any discussion, people understand this sample was biased.

The variations of the Caucasians may be due to not only sampling but also the variations of the American Caucasians themselves. The Caucasians are one race but it contains so many different ethnic groups. People can easily discuss the differences between the French and the English or others (Enlow). The author read several studies with special attention but with very few exceptions the Caucasian studies usually did not specify their samples, like Italian origin Caucasian or ethnic Spanish-Americans.

On the other hand, Japanese studies dealt with a homogeneous group, compared with American Caucasian, the Japanese have less variation themselves, and this condition may produce the similarity of results between the Japanese studies. Another factor of the similarity of Japanese studies may be due to the methods of study. The methods of Japanese cephalometric studies always refer to a study that was done by Iizuka and Ishikawa,[45] and the only differences between the Japanese studies are age group and the sample size. Of course, the sample conditions are also different from each other, but for some unknown reason Japanese studies prefer to chase population norms over "Ideal" normals.

C. JAPANESE VS. JAPANESE

1) DOWNS ANALYSIS

When compared with this study and the other three studies (Kayukawa, Iizuka, Ishikawa, and Yamauch), the angle of convexity of the Kayukawa study, the interincisal angle of Iizuka, Ishikawa study (male), and the $\underline{1}$ to A-Po of the Iizuka, Ishikawa (both male and female) and Yaauch (both male and female) show significant differences.

According to these facts, the samples of this study have less facial convexity than Kayukawa and the position of the maxillary central incisors are more posteriorly orientated. The differences of the saples of this study show well the average Japanese facial pattern.

However, the difference of the $\underline{1}$ to A-Po of Iizuka, Ishikawa, and Yamauch from this study may be explained by the difference in the way they pick A point. The male and female measurements of $\underline{1}$ to A-Po are close together in each study.

2) STEINER ANALYSIS

When discussing differences between the three Japanese studies, these individual differences should be noted. The study of Shishikura contained only male adults. The numbers of Uesato Kinoshita was a composite made up of individual means; that was closest to the means of the measurement. Only the study of Matsuura contained young adults of both sexes. Because of these conditions, "t" tests were not made between this study (female) and the study of Shishikura.

Comparing this study with other Japanese studies (Shishikara, Matsuura, and Uesato, Kinoshita), large significant differences are seen 1) $\underline{1}$ to N-A (mm.) 2) $\overline{1}$ to N-B (mm.) and 3) Go-Gn-S-N, and smaller significant differences are seen S-N-A, $\underline{1}$ to N-A (degree) and interincisal angle.

According to these facts, the major difference between the samples of this study and the samples of the other Japanese studies are the incisor position in the face and Go-Gn-S-N. The differences of the incisor position are explained by different conditions of the sampling. Shishikura picked his samples under the condition of good facial balance; Uesato Kinoshita chose the sample for the subjective determination of the ideal; Matsuura also had a condition (good profile) in his sampling. If the result of these studies, Shishikura, Uesato Kinoshita, and Matsuura, were because of the conditions that contained good facial balance or good profile, the good face of Japanese is a straight type profile similar to the Hollywood star type. There is no information to indicate why these studies chose straight type faces for good profile, but this may indicate the Western influence in Japanese society.

The difference of Go-Gn-S-N may also be explained by the lack of difference between the samples. In this study, even though there is no significant difference between males and females, the means of the measurements are divided and comparisions made individually of both the male group and the female group but Uesato Kinoshita used mixed samples and picked up an individual case that was closest to the mean values. Matsuura also used mixed samples. If this study combined males and females toghether, the mean would be between 34 to 35, making it similar to that of other studies.

3) RICKETTS ANALYSIS

Compared with this study, Ricketts Japanese norms show smaller maxillary and mandibular incisor protrusions both for male and female. Ricketts Japanese also show smaller mandibular planes than this study for female. Ricketts Japanese norms show a much smaller posterior facial height and smaller Porion location than this study for male.

These facts indicate that the Japanese of this study have more protrusive anterior incisors in both arches. The larger posterior height and steep mandibular plane could explain the difference of the ratios between the anterior facial height and posterior facial height, but there are no measurements to show this difference.

Although Ricketts Japanese norms and this study show close skeletal and dental patterns, they do have minor differences.

CHAPTER VI.

CONCLUSION

The normal variations of the skeletal pattern and the denture pattern of the seventeen year old Japanese males and females were presented by using several analyses.

There are no significant differences between Japanese males and Japanese females except the size of the head and the shape and size of the mandible. The linear measurement that relates to skeletal pattern, show that the Japannese male is larger than the Japanese female in size. The sex differences also are reflected by a different ratio between the anterior structures and the posterior structures. The sex difference in the Japanese face is more significant in the posterior structures than in the anterior structures. This means from the viewpoint of the male structure, the female structures do not develop at the same ratio as do the male.

Some differences were seen between Japanese and Caucasians. In the skeletal pattern all analyses except Downs' analysis show the Japanese have a retrusive profile or retrusive jaws in relation to the cranial base. Even the Downs' analysis, the Michigan study and the Alabama study show Japanese have a posteriorly oriented chin by the difference of the Y axis measurement.

The other difference is that Japanese have a larger mandibular plane angle than Caucasians. The Ricketts analysis indicates the difference is not only in the mandibular plane, but also that the anterior VS. posterior vertical ratios of Japanese are different from Caucasians. (Miura reported the similar result in his article of 1960).

In the denture pattern all the analyses agree that Japanese incisors are more anteriorly oriented than those of Caucasians. That indicates that the Japanese have more protrusive incisors than Caucasians.

The differences between this study and the other Japanese studies are smaller than the differences between this study and the Caucasian studies. The common differences between this study and the other Japanese studies are the relationships of the incisors to the reference planes. The incisor positions of this study are more retrusive than all the studies that were reported by using Downs analysis, Kayukawa, Iizuka and Ishikawa and Yamauch, but are more protrusive than all the studies that were done by using the Steiner analysis, and Ricketts' norms.

However, N-S-Go-Gn is the only other measurement from the sample in this study that is significantly different when compared to the average Japanese as determined by previous cephalometric studies.

SUMMARY

Seventy-nine articles were reviewed from a historical viewpoint. The following questions were asked: what are the norms for Japanese, what is the difference between Japanese males and Japanese females, what is the difference between Japanese and Caucasians and what is the difference between this study and the other Japanese studies?

A. The norm for the Japanese was presented in the results section.

B. The sex differences between the Japanese male and the Japanese female are as follows: 1) There are no significant differences of the angular measurements between male and female except Go-Gn-S-N, Facial taper and the sum of the saddle angle, articular angle and gonial angle. 2) Japanese males are larger than Japanese females in acutual size. 3) The sex difference is more significant in the posterior structures than in the anterior structures. These facts indicate that from the viewpoint of the male structure, the female structures do not develop at the same ratio as do the male structures.

C. The difference between Japanese and Caucasians are as follows: 1) The Japanese have a retrusive profile or retrusive jaws relating to the cranial base. 2) The Japanese have different vertical ratios of the anterior and posterior facial structure from Caucasians. 3) Japanese incisors are more anteriorly oriented than Caucasian.

D. The difference between this study and the other Japanese studies are the position of the incisors. In all other measurements, the samples of this study relate well to the Japanese population when comparing them to the results of previous Japanes studies.

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A.J.O. - American Journal of Orthodontics

A.O. - Angle Orthodontist

J.J.O.Sc. - Journal of Japanese Orthodontic Society

J.O.U.D.S. - Journal of Osaka University Dental School

Kobyoshi - Kokubyogakkaizashi

A.J.O.O.S. - American Journal of Orthodontics and Oral Surgery

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

April 2, 1980
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