A CEPHALOMETRIC ANALYSIS OF A NORTH AMERICAN INDIAN TRIBE:

A CROSS SECTIONAL STUDY

A Thesis

Presented to

The Faculty of Graduate Studies

University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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February 1978

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ACKNOWLEDGEMENTS

This investigation could not have been carried to its completion without the co-operation of many people. Although the names of most of them do not appear here, I gratefully acknowledge my indebtedness to all those who have contributed either directly or indirectly to this study.

I would like to express my sincere appreciation to Dr. L.C. Melosky, Assistant Professor and Clinical Director, Department of Preventive Dental Science, for his advice and supervision during the past two and half years of my orthodontic education. I am grateful for having had the opportunity to benefit from his knowledge and expertise.

I wish to thank Dr. C.L.B. Lavelle, Professor and Head, Department of Oral Biology, for his guidance, supervision and constant encouragement throughout this project.

I would like to thank Dr. A.T. Storey, Professor and Head, Department of Preventive Dental Science, for his valuable literary and research assistance.

Thanks are due to Drs. E. Cohen, F. Hechter, M. Rudisaille and J. Winburn III, Department of Preventive Dental Science, who have made my graduate education an enjoyable and worthwhile experience.

A special thank to Dr. F. Chebib, Biostatitician, Department of Preventive Dental Science, for his assistance with the computer programing and interpretation of the data.

Sincere appreciation is expressed to Mr. A. Domokos, Mr. J. Kostur, Mrs. J. Biggs-Levin and Ms. D. Barrow for their tireless help with the photography and art work.

I wish to acknowledge the help of Mrs. M.L. Kmety and Ms. M. Reid and thank them for their prompt and excellent typing.

I would like to acknowledge the students in the Orthodontic Program both past and present. In particular I would like to thank my classmates, Dr. Terry Carlyle and Dr. Ayman Chamma for their friendship, encouragement and academic guidance offered over the past two and a half years.

Finally my deepest appreciation goes to my wife Colleen, not only for her patience and help in the preparation of this thesis but also for her unfailing support and understanding throughout the course.

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ABSTRACT

The present cephalometric investigation was undertaken to determine the normal range and variation that constitutes the facial skeleton of the North American Indian child living on the Peguis Indian Reserve in Manitoba and to determine if these measurements are statistically different from those of Winnipeg Caucasian children.

The test sample comprised 114 Indian children residing on the Peguis Indian Reserve and the control sample of 163 Caucasians living in and around Metropolitan Winnipeg. The ages ranged from 8-18 years in both the Indian and control samples: both samples were grouped according to sex and age.

Linear and angular measurements obtained from the lateral cephalometric radiographs were used to evaluate and compare the two populations. The results of the univariate analysis, discriminant function analysis, acceptable occlusion assessment and the analysis of the hand-wrist films warrant the following conclusions:

1) The linear measurements of the Indian group were larger than the control group, indicating that the overall size of the cranio-facial complex was greater in the Indian than in the Caucasian group for all age categories.

2) There was a trend towards sexual dimorphism with the males generally larger than the females.

3) The Indians displayed a more anteriorly positioned maxilla, steeper mandibular plane (to sella-nasion or Frankfort Horizontal) and protrusive maxillary incisors. The Indian group may also be described as having a convex mesognathic profile with the skeletal chin point in harmony with the face.

4) The six discriminant function analyses revealed that the best discriminators were the relationship of orbitale to SN, the vertical height of pogonion in relation to the mandibular plane and the relationship of the lower incisor to NB.

5) The discriminant analyses revealed that the Indian sample was more homogeneous than the control group.

6) The skeletal and dental patterns of the Indian and Caucasian acceptable occlusion groups were very similar with the exception of the steeper mandibular plane angle and the more protrusive maxilla of the Indian.

7) The cephalometric norms of the Manitoba analysis are applicable to the Indian child living on the Peguis Indian Reserve.

8) Although the skeletal age of the Indian sample was slightly retarded in relation to the chronologic age, the fact that the skeletal age was generally within one year of the chronologic age, warrants the conclusion that there was an acceptable chronologic/skeletal age relationship in the Indian group.

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Introduction

The literature contains numerous publications on the variation in the craniofacial skeleton and soft tissue configuration of various ethnic groups. For example, there is excellent data on Negroes (Cotton, 1950; Altemus, 1960; McDonald, 1975): Japanese (Takano, 1950; Hoshino, 1970); Australian Aborigines (Craven, 1952; Barrett, 1963); Eskimo (Colby, 1972) to name a few. On the other hand there are few such studies reported in the literature pertaining to the North American Indian (Teal, 1953; Jensen, 1972).

The importance of racial background in the practice of Orthodontics lies in the fact that different ethnic groups display a variation in skeletal growth and structural patterns (Colby, 1972; Altemus, 1960). Since the orthodontist makes use of cephalometric norms or standards for diagnosis and treatment planning, the treatment planning of the North American Indian may be different from the Caucasian. Therefore, if a particular skeletal pattern for this race can be determined, a better model for orthodontic treatment goals can possibly be achieved.

The present investigation of lateral cephalograms was undertaken to determine the normal range and variation that constitutes the average profile of the North American Indian child living on the Peguis Indian Reserve in Manitoba and to determine if in fact, these measurements are statistically different from those of

Winnipeg Caucasian children. If skeletal differences are present, then treatment plans and clinical procedures have to be altered from one racial group to another (Downs, 1956). Therefore, the orthodontist should have a thorough understanding of the differences between the races and the normal ranges for each ethnic group.

In summary this study was conducted with the following aims:

1. To document and define by selective and random sampling the physical characteristics of the Indian face.
2. Obtain a cephalometric analysis of Indian children with "acceptable" occlusion and from this, develop orthodontic norms to be used in treatment planning.
3. Determine the craniofacial developmental differences between the Peguis Indian children and the Caucasian children in the Winnipeg area.
4. Utilizing hand-wrist films, assess growth trends of the Indian sample by comparing chronological and skeletal ages.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF THE LITERATURE

Origin of the North American Indian

The origin of the American aborigine has been a subject of profound interest ever since the Europeans first reached the "New World" in the latter 15th century.

The North American Indian is generally accepted by most anthropologists as a subdivision of the Mongoloid stock (Huxley, 1901). From various anthropologic evidence, it is currently felt that the North American Indian and Mongoloids of Asia evolved separately from a common ancestral group living during the Upper Paleolithic Period (Wissler, 1931). This has resulted in a similarity in skin texture, color range, hair form, hair texture, hair distribution and shovel shaped incisors between the American Indians and Asiatic Mongoloids (Wissler, 1931; Coon, 1962).

Craniofacially, the differences between the American Indian and the Asiatic Mongoloids are found principally in certain facial features. Clinical observation reveals that the Indians show less facial flatness than the Asiatic Mongoloids and have more prominent noses with convex profiles (Coon, 1965).

Archaelogical evidence shows that man first appeared in the New World before 10,000 B.C. (Willey, 1966), or possibly as early as 40,000 to 20,000 B.C., although these dates may be revised in view of future findings. During the period between 21,000 B.C. and 11,000 B.C., a Bering Strait land bridge was present (Laughlin, 1967;

Josephy, 1969) and it is logical to assume that there were a series of migrations, with the coastal inhabitants being ancestors of the Eskimo and the interior inhabitants ancestors of the American Indian (Laughlin, 1967).

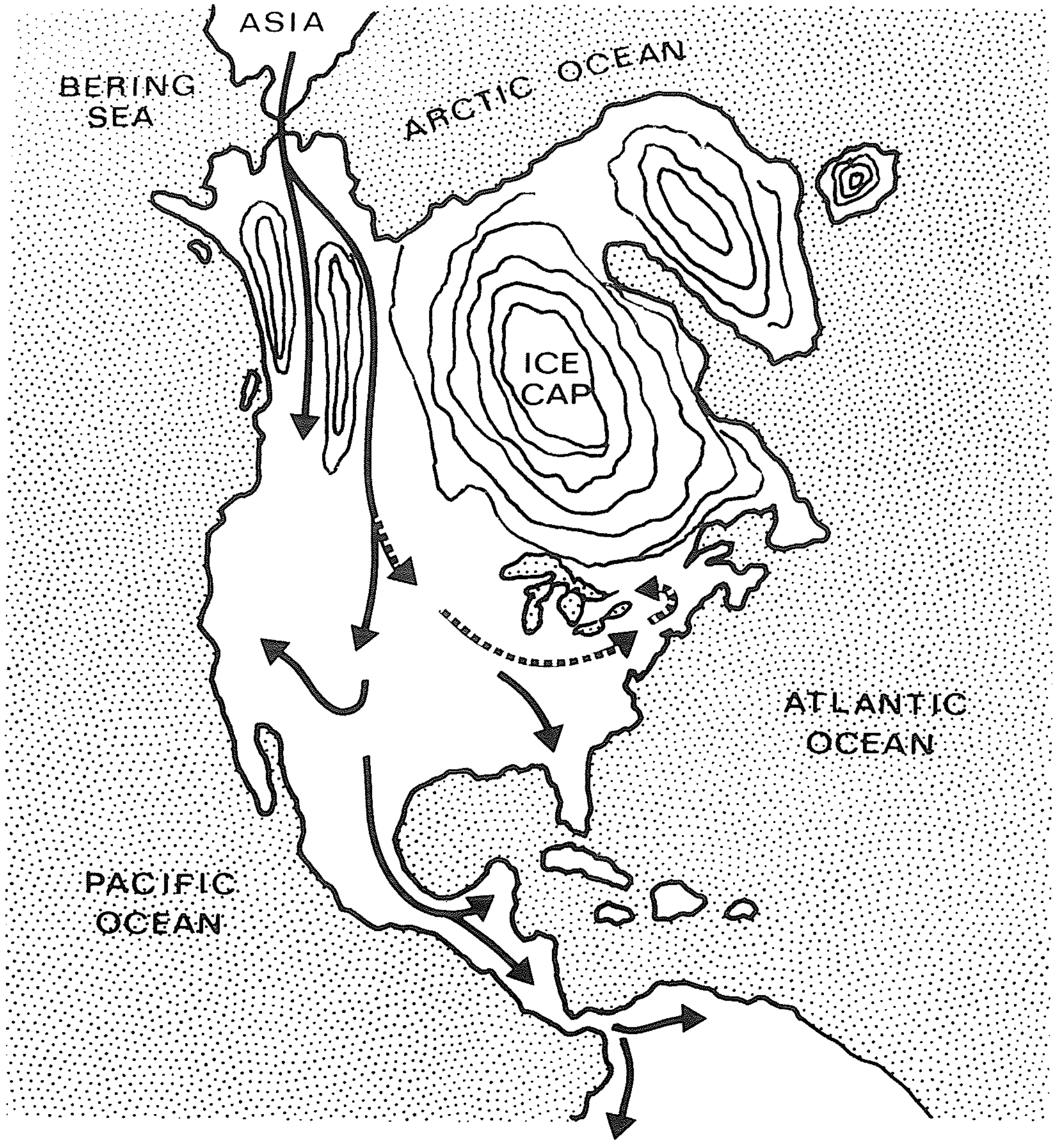
Man is known to have been in the Northeastern area of North America for at least 11,000 years, probably having spread into it from the west or south after migrations from Alaska (Denig, 1961). The people were nomadic hunters and as the ice age retreated and the climate warmed, they moved north and west into the Great Lakes area (Griffin, 1952) (Figure 1).

Origin of the Ojibwa

The Ojibwa were part of a large body of Algonkian speaking Indians who came from the eastern part of North America (Josephy, 1969). Upon reaching the Mackinac area, at the northern tip of Michigan's lower peninsula, this group separated into three tribes; the Ojibwa, the Ottawa and the Potawatomi (Kinietz, 1965). The Ojibwa occupied the area around Sault-Saint Marie, in Michigan and Ontario and eventually moved west along both shores of Lake Superior. The Ottawa and Potawatomi tribes located further south on the lower Michigan peninsula.

In the eighteenth century, the Ojibwa began to expand in both territory and population. Some Ojibwa bands begun to move east around Lake Huron, while others pushed west into the present states of Wisconsin and Minnesota, as well as the western reaches

Figure 1. Probable routes of early man in North America (after Josephy, 1969).



-------- Probable Origin of Man in the Great Lakes Area.

Early Man in North America

of the province of Ontario (Howard, 1965). Possessing the desire for adventure and exploration, they moved west primarily in search of new hunting and trapping areas (Kinietz, 1965).

By the middle of the eighteenth century, the Ojibwa had expanded west and displaced the Cree around the Lake Winnipeg drainage system (Hickerson, 1970). These Ojibwa who came to occupy the Lake Winnipeg area, moved west from the many scattered and isolated locations in Northwestern Ontario. The main arteries of this generally westward movement included the Poplar, Berens, Bloodvein, Wanipigow, Manigotogan, Little Black, Winnipeg, Broken-head and Roseau rivers. This resulted in one of the largest Indian tribes of the Canadian prairie region (Steinbring, 1974). This tribe is frequently referred to by various names, the more common ones being, the Bungi, Plains-Ojibwa, Chippewa and Saulteaux (Howard, 1965). Initially, the prairie region was a strange and unfamiliar environment to these woodland people, yet within a century (1790-1890), they had sucessfully reoriented their culture and had become excellent farmers (Steinbring, 1964).

One of the more reliable accounts of the origin of the group is Chief Albert E. Thompson's book entitled <u>Chief Peguis and His Descendants</u> (1973). Chief Thompson is Chief Peguis's great great grandson. He related the story of Chief Peguis and a band of Saulteaux Indians who came from the Sault-Saint Marie area to the Red River country in the latter part of the 1790's. This group apparently had no real destination in mind when they left the Sault area and travelled westward in search of fish, waterfowl and game. They paddled into Lake Winnipeg along the eastern shore and headed south to the mouth of the Red River. Here a small stream flowing from the west was followed and they named it "Ne-poo-win" or Netley Creek. They decided to settle in this area as fish and game were plentiful. Later they explored south along the Red River to the mouth of the Assiniboine River. Here they encountered the Assiniboine tribe with whom they became allies against their common enemy from the Dakotas, the Sioux (Thompson, 1973).

In the early eighteen hundreds, with the fur trade thriving for both the rival Hudson's Bay Company and the North West Company, trouble arose when the Hudson's Bay Company sold Lord Selkirk 116,000 acres of land to be used for settlement. The settlers arrived in 1814 and were aided by the Saulteaux, as it was mid summer and too late to plant a crop for the season. The North Westers fearing the settlers would interfere with the fur trade, massacred a number of them on June 18, 1816 at Seven Oaks (Martin, 1966). Chief Peguis aided the survivors and gave them refuge at Netley Creek, before they moved to Norway House to spend the winter.

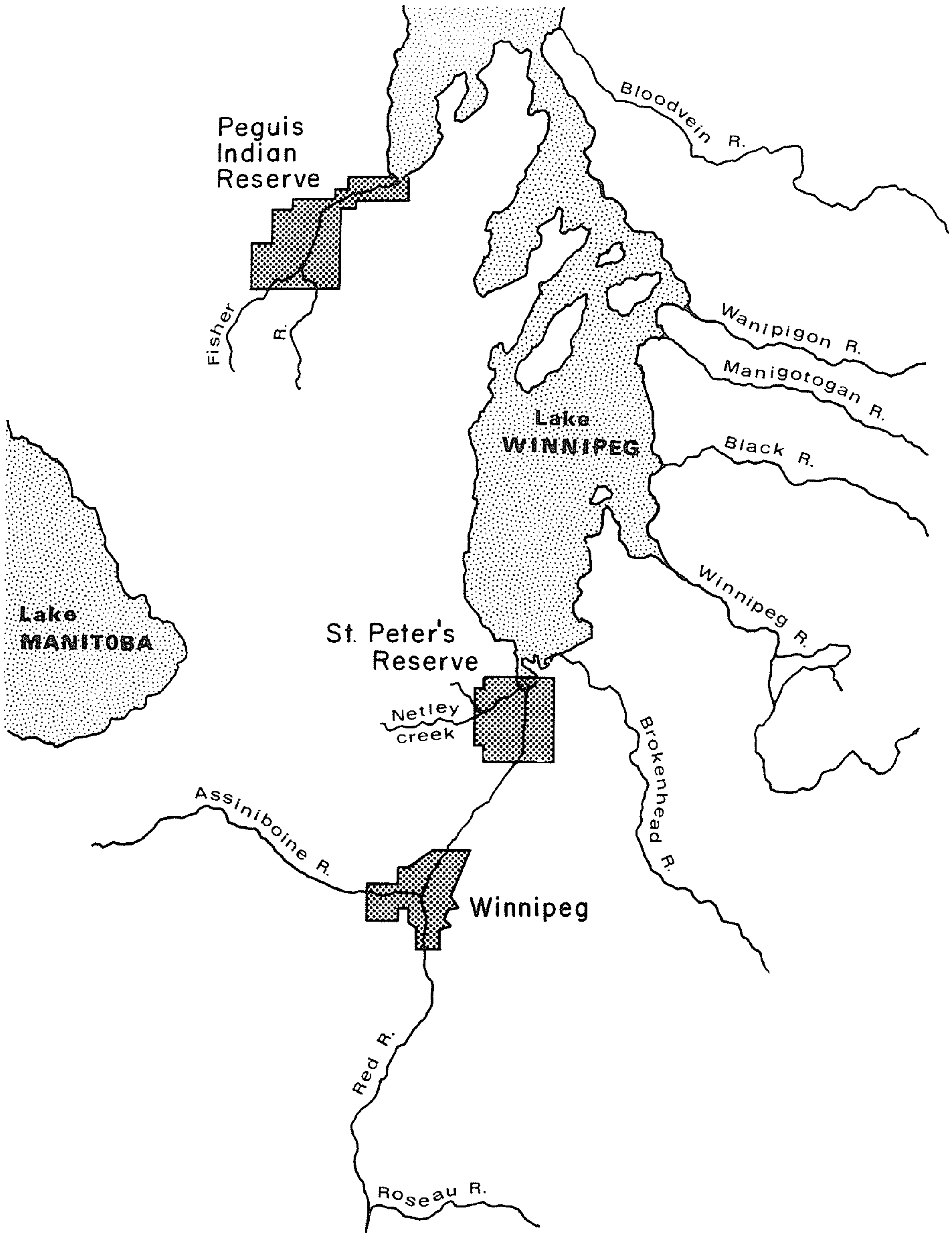
Initially, the Indian's main source of food was hunting wild game but due to a diminishing food supply, they were instructed by the Selkirk settlers in the basics of farming. In 1832, they harvested their first crop. This tribe has since become one of the most successful Indian farming groups in Manitoba (Steinbring, 1964).

Chief Peguis and his tribe were converted to the Christian faith in 1838. The tribe was well established at the St. Peter's reserve when Chief Peguis died at the age of 90, on September 28, 1964.

In 1909 the Saulteaux surrendered approximately 48,000 acres, "being composed of the whole of St. Peters Indian Reserve" for the sum of $5,000 (Thompson, 1973). Their new reserve was to be situated on 75,000 acres adjacent to Lake Winnipeg and to include not more than ten miles of water front. They were forced by the government officials and land "speculators" to relinquish prime agricultural land in exchange for a heavily wooded area. A majority vote to surrender the reserve before the Indians could be adequately informed of the consequences was obtained by trickery, bribery and alcohol (Thompson, 1973). The land was acquired at two dollars per acre and later sold for twenty dollars per acre. The Saulteaux then moved to their present location, 100 miles north of St. Peters Reserve, where the Fisher River flows into Lake Winnipeg. There was great hardship for a number of years as there were no homes or cleared land at their new location (Figure 2).

The Peguis Indian Reserve is considered to be mainly Saulteaux in origin (Thompson, 1973). There is little doubt now that there has been intermarriage between various other Saulteaux bands in the Lake Winnipeg area, between other tribes such as the Cree and finally with whites who came in as the Selkirk settlers (Hallowell, 1955 and Steinbring, 1972). In conclusion,

Figure 2. Map showing the location of the Peguis Indian Reserve.


Peguis
Indian
Reserve
Fisher
R.
Bloodvein R.
Wanipigon R.
Manigotogan R.
Lake
WINNIPEG
Black R.
Winnipeg R.
Lake
MANITOBA
St. Peter's
Reserve
Netley
creek
Brokenhead R.
Assiniboine R.
Winnipeg
Red R.
Roseau R.

the Peguis Reserve, although predominantly Saulteaux cannot be considered a "pure" Indian tribe.

Early Anthropological Developments

Comas, in his "Manual of Physical Anthropology" (1960), reviews early anthropometry. He mentions Heroditus, Hippocrates, Aristotle, Galen and many others who have left written records of anthropometry from several hundred years before Christ.

In the sixteenth century, Vesalius, a pioneer in racial craniology, noted the "globular" skull in Genoese, Greeks and Turks, the flattened occiput and round head of the Germans, and the "oblong" skull of the Belgians.

The first evidence of the application of precision instruments to the measurement of the human skull appears to be the work performed by de Palissy. Van den Spieghel applied Palissy's ideas and make the first practical experiment when he measured and grouped skull forms according to four dimensions.

Doubenton is credited with the first serious application of craniometry. He was interested in the foramen magnum, especially in the progression from the carnivores to man (Comas, 1960).

Camper, in 1780, was the first to employ angles in measuring the face. He described the usefulness of the angle formed by the intersection of a line from the base of the nose to the external auditory meatus with a line tangent to the facial profile (most prominent point on the forehead to the alveolar margin of the upper jaw). This line has since lost popularity because of its extreme variability within a race or ethnic group.

The International Congress of Anthropology in Frankfort, Germany (1884) accepted Von Ihering's line as a standard plane of orientation. This line has since become known as the "Frankfort Horizontal Plane" which presently is a basis of roentogenographic cephalometric orientation (Allen, 1963).

A detailed historical resume of the earlier methods used in studying the various facial profiles is given by Bjork (1947) in his book "The Face in Profile". The protrusion of the jaws beyond vertical planes drawn at right angles to the Frankfort Horizontal plane have been assessed by various investigators using linear measurements. To cite a few, Consorte, Schroeder and Dreyfus (1922), drew a vertical plane through nasion; Simon (1922) drew a line through orbitale; Izard (1931) used glabella and later illustrated various facial angles in Australian aboriginals, African Negroes and Europeans.

The face and occlusion in contrasting racial groups was examined by Hellman (1927b) using craniometry. The sample consisted of 22 European white, 35 Australian aboriginal and 56 Hindu skulls. He showed the Australian aboriginal face to be further forward than the other two races.

The craniofacial complex as a whole, as well as the individual structures, display racial characteristics. For example, Izard (1927) investigated the gonial angle of various groups. He found the average gonial angle for Eskimos to be 115°, Asiatic races and American Indians 115° to 120°, African Negroes 120° to 125° and European races vary from 125° to 128°. He observed this angle to vary less from individual to individual in the "pure" races as compared to modern races.

Hrdlicka (1940) in an extensive anthropological study of 3006 adult skulls (1492 male, 1514 female) of different races (White, Indian, Eskimo, Mongol) concluded that the gonial angle displayed definite racial as well as sexual characteristics. For example, the gonial angle was found to be highest (most oblique) in the Whites, and lowest (nearest to a right angle) in the American Indian. The mean gonial angle was also found to be higher in the females than the males.

Basically, there are two approaches dealing with facial components: the anthropological and the roentgenographic. The anthropological method consists of photography and direct examination of dry skulls as the manner of recording human phenotypes. This technique is especially useful in tracing certain races to their common ancestors. When dealing with living specimens its limitations lay in the inaccuracy of locating landmarks due to presence of soft tissue and the inability of studying intracranial structures.

Since the introduction of the Broadbent-Bolton cephalometer (1931), it has been possible to examine bony landmarks in subjects from a frontal and sagittal aspect. More information has become available about the internal structures. A wider selection of reference points and planes are now possible by using previously inaccessible facial and intra and extra cranial landmarks. A great number of investigations concerning the facial skeleton have been performed, many on measurements taken from subjects presenting a good occlusion and profile in an attempt to establish facial standards or goals in orthodontic treatment.

Cephalometric Studies of Various Ethnic Groups

Bjork (1951a) was one of the first researchers to utilize cephalometric radiographs to compare the craniofacial morphology of racial groups. This study has since been followed by several other investigations of ethnic groups by various authors, some of which are reviewed briefly below.

Various classification systems of ethnic and racial groups are presently in vogue. In this study, the following generalized classification was selected to minimize controversy.

a) Negroid Studies

i. American

Of the racial groups, this is the most extensively investigated group. Cotton (1951) studied 20 Negroes from the San Francisco Bay area, equally divided by sex. The ages ranged from 11 to 34. In contrast to Downs, Cotton did not select his sample on the basis of excellent occlusion, although there were no "real" malocclusions. He found the Negro sample to have an angle of convexity indicating relative protrusion of the maxillary arch at its anterior limit in relation to the total profile.

Nodiot (1958) investigated the skeletal pattern of 99 American Negro children whose age ranged from 11.1 to 13.1 years (47 males and 52 females). He found no significant differences in the angle of the cranial base, Ba-S-N. The length of the mandible was noted to be longer in the female group. The axis of the upper incisor was more upright in the male subjects and the degree of anterior overjet and overbite was more severe in this group as well.

The head and face of eighty, 12-16 year old American Negro children equally divided by sex, were studied by Altemus (1960). The main objective of his study was to determine cephalofacial relationships of American Negro children with normal occlusion. A significant observation was the larger size of the heads and faces of the North American Negro as compared to the North American Cuacasian of the same age. He also observed that the skeletal patterns of the Negro and the Caucasian were similar. The prognathism of the Negro was found to be dental. Altemus, as previous authors (Takano, 1950; Wong, 1950), concluded that the norms and standards of one racial group cannot be used without modification for another racial group. However, he does state "The range of normal variability within the group is very great, as it has been shown in other racial groups". Altemus warned against rigidly adhering to standards and norms because of the variability within a racial group.

Thomas (1967) studied 50 Negro males between the ages of 12 and 16 years, all of whom had "harmonious facial balance" and excellent occlusion. One of his more pertinent findings was an inverse relationship between the vertical and sagittal extensions of the face. Large horizontal plane angles (palatal, mandibular and occlusal) were associated with increased facial height and retrognathism, while more acute cranial base angles and relatively horizontal planes are associated with prognathism.

In the following year (1968), Drummond designed a study to determine a mean and range for lateral cephalometric measurements in the American Negro. Statistical analysis was used to compare the means obtained from 40 male and female American Negro patients (age 8 - 23 years) with clinically acceptable occlusion (Angle Class I molar relationship) with the accepted means for the Caucasoids. The primary difference was found to be the bimaxillary dental protrusion, the steep mandibular plane and the anterior placement of the maxilla in the Negro population.

Smith (1970) attempted to compare 22 Negroes between ages of 15 and 25 years, who possessed acceptable occlusions and pleasing profiles to the norms developed by Tweed (1954), Steiner (1953) and Ricketts (1960). His findings were similar to the previous authors, (Altemus, 1960; Drummond, 1968; Smith, 1970) in that a more forward positioning of the maxilla and protrusion of the incisors were noted in the Negroid.

McDonald (1975) conducted a study to obtain cephalometric standards for 24 Negroes male and female children with a mean age of twelve years. His findings were also similar to previous authors in that all the linear measurements were found to be larger in the Negroes except for the chin button (Altemus, 1960). The denture bases of the Negroid sample were more prominent in relation to the crania and the incisors were more flared and bodily forward. These results and others (Smith, 1970; Drummond, 1968; Altemus, 1960 and Cotton, 1950) have shown that existing Caucasoid standards should not be applied to Negroid patients.

In summary, the American Negroid craniofacial pattern is characterized by the larger linear dimensions, a large angle of convexity, a steep mandibular plane angle as well as a bi-maxillary dental protrusion.

ii. African

Bjork (1951a) compared 400 South African Bantus with 603 Swedes. He observed the jaws of the Bantus to be larger than the Swedes when related to the cranial base. The cranial base angle (Na-S-Ba) was flatter and the foramen magnum was located in a more dorsal position on the underside of the skull in the Bantus. He also devised a facial polygon which has since been used in several cephalometric studies of various races.

A very small sample (13) of selected male and female African subjects with excellent occlusion was examined by Jacobson and Dryer (1956). They were compared to Caucasoid standards from the Down's analysis. It was found that the facial skeletal patterns of both ethnic groups were remarkably similar. The denture pattern differed in that the African presented larger teeth and true dental prognathism accompanied by heavy flaccid musculature. Their conclusion was similar to others (Takano, 1950; Wong, 1950; Altemus, 1960; Drummond, 1968 and McDonald, 1975) in that they felt there should be separate norms or standards for each ethnic group as variation between ethnic groups is the rule and not the exception.

iii. African -"White/Black"

Kowalski *et al* (1975) investigated the craniofacial morphology of 149 male and 105 female Nubian school children (an admixture of Negroid and Caucasoid blood; Encyclopaedia Britannica) ranging in age from 6 to 18 years. Their sample was considered to be representative of the "normal" variation in the Nubian population. The craniofacial measurements were compared with corresponding results of "normal" American Caucasoid children (Walker, 1971). The Nubian sample showed a much higher degree of bimaxillary protrusion and smaller SNA and SNB angles than the Caucasoid children. The mandibular incisor - mandibular plane angle was similar in both groups and no evidence of sexual dimorphism was present.

b) Caucasoid

Barnes (1954) conducted a serial cephalometric growth study upon a group of North American Caucasoid children between the ages of 12 and 15 years. The sample consisted of 16 males and 18 females, all possessing excellent occlusion. He attempted to evaluate the growth and development of the facial complex between these two ages and reached the following conclusions. The females tended to mature and have their most rapid growth period earlier than males. The age changes in the facial skeleton tended to be characterized by increased protrusion of the chin point and a lessening of the convexity of the face. The maturation changes associated with the denture was that of a decrease of the protrusion of the anterior teeth. He concluded that these facts were of the utmost importance to the clinical orthodontist if proper diagnosis and treatment planning were to be accomplished.

Wasserberger (1956) found the facial profile of an unknown number of 9 year old Caucasian children with excellent occlusion differs from that of children without excellent occlusion. The differences noted were in protrusion of the dentition, the relationship of apical bases and the inclination of the mandibular planes.

Gresham (1963) made a comparative study of the facial and dental patterns in children of the same ethnic origin but living in two different countries, North America and New Zealand. All the 44 subjects in each group were of the same sex, age and type of occlusion (Class I, acceptable). He observed an overall marked similarity in the basic skeletal pattern between the two groups of children although a significant reduction of the facial height of the North American group was noted, (ie., a difference in size rather than form). Dentally he found a procumbency of the incisor teeth in the North American child, mainly due to an increase in angulation rather than due to a variation to either the anterior cranial base or the mandible.

In 1965, Taylor and Hitchcock developed the Alabama cephalometric analysis for southern Caucasoid children. Overall they found no appreciable craniofacial differences between northern and southern Caucasoid children. However, there were significant differences between the two groups regarding the teeth and the occlusal plane.

Brown (1973) conducted a cephalometric study involving 45 Northern Irish families with two parents and at least four children. His primary objective was to determine heredity patterns that were present. He concluded after analyzing the various measurements that greater similarities exist within families than between families and there is more similarity between parents and children of the same sex.

Lavelle (1974) studied 100 British Caucasoids and a similar number of British born West African Negroes between the ages of 17-27 years. The sample was equally divided by sex and the selection was based on good hygiene, acceptable occlusion, pleasing profile and no history of orthodontic treatment. Univariate and multivariate statistical analyses were performed. A definite sexual dimorphism was found, with the males in each group being the larger. He found the angle of convexity to be the most discriminating feature between the two population samples and if this variable was excluded, the skeletal pattern of the Caucasoid and Negroid were similar.

Using a sample size of sixty subjects, Cannavati (1967) and Kennedy (1969) performed a cephalometric study to determine standards for Latin American children of the ages 4 through 7. Other than a larger ANB angle in the younger children, there were no further significant findings.

Salazar (1970) selected a sample consisting of 20 Latin American children ranging in age from 12-19 years, with the mean age of 15 years 11 months. The criteria for sample selection was acceptable facial profiles and clinically acceptable Class I normal occlusion. The statistical analysis indicated that all the Down's (1948) measurements differed significantly, with the exception of the facial angle, the A-B plane and occlusal plane to Frankfort Horizontal. A tendency towards bimaxillary protrusion was noted.

Nanda (1969) compared the dentofacial pattern of 50 North (Lucknow) Hindus, who were selected for their excellent dento-facial harmony and proportions. They were compared to Caucasoids (Down's, 1948), Chinese (Wong, 1950), Negro (Altemus, 1960) and Japanese (Takano, 1950) using the Down's cephalometric analysis. The significant findings were noted to be a similar skeletal pattern when compared to the American Caucasoids but a retrusive pattern in comparison to the Chinese, Negro and Japanese. The dental pattern was protrusive in comparison to the Caucasoid, retrusive compared to the Chinese and Negro and very similar to the Japanese. He concludes by stating "the excellence of dentofacial pattern is peculiar to its racial group".

c) Mongoloid

For ease of reading, the Mongoloids have been arbitrarily separated into a number of subgroups:

i. Chinese

Wong (1950) conducted a study of 20 American Chinese of San Francisco Chinatown. The sample ranged in age from 11 to 16 years and also had an equal number of males and females. The criteria for selection was excellent occlusion and good harmony. Wong's conclusion was similar to Takano, ie., that Downs'cephalometric analysis was not applicable to the Chinese of San Francisco. When compared to Downs' normals, the Chinese presented a Class II facial pattern even though they exhibited a good facial profile and normal occlusion. He felt that his norm for the race should be considered when dealing with the Chinese of San Francisco.

Chan (1972) compared cephalometric findings of the Chinese to other studies of Caucasoid, Negroid, Japanese and Australian aborigines. He concluded that the Chinese sample has the most retrognathic mandible and had marked bimaxillary and dental protrusion when compared to Caucasoid standards as well as the largest mandibular plane angle.

ii. Japanese

Takano (1950) observed the variations in facial relationship of 20 adult Nisei (American born Japanese) with a mean age of 21. There was an equal number of males and females which were selected on the basis of excellent occlusion and good facial harmony. Takano found the skeletal pattern of the Japanese to be significantly different from the Caucasian group (Downs' sample) with regard to the angle of convexity and the "Y" axis angle measurements. Dentally the following significant differences were observed. The Japanese displayed a smaller interincisal angle (126°), larger mandibular incisor to occlusal and mandibular plane angles as well as a more anteriorly positioned maxillary incisor in relationship to the A-P plane. In other words, the skeletal and dental patterns are significantly more protrusive in the Nisei group than in the Caucasoid group. In his conclusion, he stated " it is fallacious to apply morphological standards derived in one ethnic group to the individuals of another".

Hatasaka (1964) studied an unknown number of third generation Japanese American children (Sansei) with excellent occlusion. His objectives were to establish reference standards and to compare them with available measurements on the Nisei and Caucasoids. He concluded that the Sansei did not display the retrognathic position of the mandible which appeared to be a prominent characteristic in the native Japanese. The faces of the third generation Japanese in American were found to be less convex and teeth less prominent than the second generation Japanese in America.

Uesata (1968) reviewed a number of studies and data to illustrate certain dentofacial differences among Japanese, American-Japanese and Caucasoids. The Japanese skeletal pattern shows a definite tendency towards a Class II, whereas the American-Japanese deviate slightly from the Caucasoid pattern. He also found the maxillary and mandibular incisors of both groups are positioned further anterior in the dental arch than the Caucasoids. He noted that the criteria used for ethnic balance are strictly arbitrary or subjective and stated that his concept of the esthetically balanced facial profile for the American Japanese was realized when the upper and lower lips are contained within the "E" (Ricketts, 1960) and "S" (Steiner, 1962) lines.

Hoshino (1970) studied 22 American Japanese exhibiting Class I molar relationships, who ranged in age from 6 - 18 years. He found similar growth trends present as had been determined for Caucasoids in previous studies (Barnes, 1954; Graves, 1964).

Iwasawa _et al_ (1977) selected from 118 Japanese men and women, 19 to 24 years of age, a number of subgroups, which consisted of a "normal" occlusion group, a Class II Division I group and a Class III group. The purpose was to establish an appropriate diagnostic guide for the Tweed triangle. On the basis of this study and the reports of other investigators, an FMIA of 57° was found to be the most suitable for the diagnosis of Japanese patients.

The Japanese craniofacial pattern is found to vary depending on the number of generations in America: with the greater the number of generations, the less convex is the profile and the less prominent the teeth. In summary, the Japanese craniofacial pattern is characterized by a slightly convex profile and a straight facial pattern with maxillary and mandibular incisors anteriorly positioned in the dental arch.

iii. Vietnamese

Nga (1972) in a cross-sectional cephalometric study analyzed 95 Vietnamese (44 males, 51 females) and 74 Caucasoids of European ancestry (33 males, 40 females) between the ages of 7 - 13 years. The criteria for selection was an acceptable Class I occlusion. He noted the following significant differences: the overall size of the Vietnamese facial structure is smaller than the Caucasoid; the Vietnamese face was found to be retrusive relative to the anterior cranial base, particularly the midface, and all the Vietnamese exhibited a steep mandibular plane along with a dental protrusion. It was also noted that the Vietnamese exhibited the most retrusive faces when compared to the Chinese, Negroid and Caucasoid.

iv. American Indian

Teal (1953) investigated 35 Navajo Indian children. The 14 females and 21 males ranged in age from 12 - 19 years and exhibited typical Navajo facial patterns and clinically acceptable normal occlusions. He observed that the Navajo child had a retrognathic, convex profile with broad massive features. The entire dentition is positioned anteriorly, showing a labio-version of the maxillary and mandibular incisor teeth giving the Navajo a full, prominent profile, similar in appearance to a slight Caucasoid bimaxillary protrusion.

Cole (1964) in a cephalometric study of 54 Navajo Indians of Monument Valley, Utah, used a combined Downs' (1948) and Riedel (1952) analysis and found a prognathic face with a bimaxillary protrusive denture. He also concluded that the mean values for the skeletal pattern of the Navajo most closely approximates the values of the Japanese and the dental pattern closely equates the American Negro and Chinese.

Christensen (1966) using cephalometric data performed a discriminate analysis on five North American Tribes (Papago, Pima, Apache, Mayo and Chamula). The Papago, Pima and Apache could not be distinguished from one another, while the Mayo and Chamula are clearly distinguishable from each other and the other tribes as well.

Jensen and Harris (1972) investigated 74 genetically determined full blooded Hunkpapa Sioux, 64 mixed blood Hunkpapa-Caucasoid and 137 Caucasoids from the Michigan area. The uni- and multivariate statistical analyses revealed that sexual dimorphism in all three population samples was present with the males being larger than the females in all groups. The Hunkpapa Sioux are generally larger in craniofacial dimensions than the Caucasoid. Alveolar prognathism is most pronounced in the Caucasoid.

Kowalski *et al* (1975) studied the dentofacial variation within and between four groups of adult American males. The four groups consisted of 177 "Black" Americans, 300 "White" Americans, 65 Hunkpapa Sioux and 31 Peruvian Cashinahua Indians, with all subjects ranging from 20 - 50 years. A discriminate analysis revealed that the "Black", "White" and Sioux groups, while significantly different, were much more similar to each other than any of them were to the Cashinahua. The most effective discriminator between the four groups was the lower incisor to NB angle followed by the lower incisor to NB distance. The proclination of the lower incisor to the NB line is much higher in the non-white samples. The SNB angle ranked second in discriminative value reflecting differences in mandibular prognathism. The Negroid group showed the highest degree of prognathism and the Cashinahua was the lowest.

v. Eskimo (Inuit)

Colby (1972) attempted to characterize the craniofacial phenotype of the Canadian Eskimo living in the Northern Foxe Basin, Northwest Territory. He compared 108 male and 84 female Eskimos with 73 male and 70 female Caucasoids (ages 3 - 59 years) from the Winnipeg, Manitoba area. His cross sectional study indicated that the Eskimo has a phenotype established early in life and that the overall size of the Eskimo craniofacial complex was significantly larger than the Caucasoid. The mandibular corpus length was greater in the Eskimo group, but the chin in relation to the anterior cranial base was recessive. Another finding was the more procumbent maxillary and mandibular incisors in the Eskimo group and together with the anteriorly positioned maxilla produced a bimaxillary protrusion.

vi. Hawaiian

Choy (1969) analyzed 78 Hawaiians utilizing Bjorks' (1947), Downs' (1948), Steiner's (1953) and Tweed's (1944) analyses. He concluded that of all the non Caucasoid groups (Australian Aborigine, American Negro, American Japanese, American Chinese and Japanese) the Hawaiian was found to have a more similar craniofacial pattern to that of the Caucasoids. The Hawaiian also exhibits a low mandibular and occlusal plane. Choy also found the maxillary incisors of the Hawaiians were more upright while the mandibular incisors were labially inclined.

vii. Phillippino

Sabater (1969) studied 25 non-orthodontically treated adults from the Phillippines. The sample consisted of 12 males and 13 females with a mean range of 30 and an age range of 19 to 53 years. The subjects were selected on the basis of Angle's Class I occlusion with acceptable esthetics and good facial balance. He noted the facial angle to be smaller and the angle of convexity or maxillary protrusion to be larger in the Phillippino group. They also had a steeper mandibular plane and more procumbent incisor teeth than the Caucasoids. He also compared the Phillippino to other racial groups and found the incisors more upright in the Caucasoid and procumbency of the incisors characteristics of the Phillippino, Chinese, Japanese, Indian and American Negro.

d) Australoid

In a cephalometric study on 20 teenage and young adult Australian aborigines of excellent occlusion and good facial balance, Craven (1952) observed a greater degree of alveolar prognathism in Australian Aborigines than in Swedes or Bantus.

Barrett (1965) analyzed an equal number of Australian Aboriginal children (44) and Caucasoid children from Melbourne, Australia. This study consisted of 22 males and 22 females of equal age range. He found the most marked differences between the groups of children were seen in the denture patterns. The incisor teeth were positioned more anteriorly and inclined more acutely in the Aboriginals than in the Caucasoid group. This may be due to the large mesiodistal tooth diameters of the Aboriginals.

e) Conclusion

Downs (1956) compared the studies of Cotton (1950), Takano (1950), Wong (1950) and Craven (1958) and determined that the four ethnic groups has significantly different facial patterns.

He found that the difference appeared in the much greater facial convexity. He concluded that, "Prognathism is the mean or average facial patterns of the Chinese, Japanese, Negro and Australian Aborigine". The Chinese facial pattern is most similar to the Caucasoid while the Australian Aboriginal had the greatest dental protrusion and prognathism.

In view of the preceeding studies, ethnic group differences do exist and these differences must be considered for a proper diagnosis and treatment in different races.

It is obvious, however, that as different studies incorporate various cephalometric variables determined over varying age ranges, the present data is insufficient to provide a basis for the orthodontic diagnosis and treatment of North American Indian patients.

From the brief review, therefore, there are certainly contrasts in the craniofacial profile between different ethnic groups. The reasons for such contrasts will only be revealed when the genetic and environmental factors affecting the craniofacial skeleton have been partitioned.

Skeletal Maturation

A knowledge of craniofacial growth is a necessary prerequisite to orthodontic therapy. Whether or not craniofacial growth will occur during treatment often influences the treatment plan. In addition, the timing of the adolescent growth spurt with treatment, may have a direct bearing on the degree of success in obtaining our objectives with the exception of an anterior divergent growth pattern.

Any study of adolescent growth is plagued with the fact that children mature at different rates. For example, a girl with a chronological age of 13 years may be pre-adolescent, adolescent or post-adolescent. It is, therefore, necessary to have some rating other than chronologic age to gauge an individual's progress towards maturity. Besides skeletal age, numerous maturity indicators are available, common ones being height age, weight age, sex age, and dental age. Wetzel (1941) developed the Wetzel Grid, which is a plot of height and weight of the subject. This results in an objective method of evaluating the body build, developmental level, nutritional grade, physical status and age advancement of the child when compared to the chronologic age. Woodside (1976) utilizes mandibular length measured from a 45° oblique radiograph in growth potential assessment for patients. At present, skeletal age offers the most reliable evaluation of growth and development of the body (Krogman, 1958; Greulich and Pyle, 1959; Tanner, 1962). Therefore, this maturity indicator will be reviewed in more detail.

Around the turn of this century, the use of the skeleton as an index to evaluate the growth and development of the body was introduced by various investigators (Ranke, 1896). Ranke is considered to be the first investigator to study skeletal development by means of hand and wrist radiographs.

Flory (1936) and Todd (1937) independently developed hand and wrist radiographic methods to evaluate the progress of skeletal growth. Todd (1937) was the first to publish an atlas which was utilized by comparing the overall appearance of the standards, with a given radiograph of the hand and wrist. This has become known as the Inspectional Technique.

In 1950, Greulich and Pyle first published their Radiographic Atlas of Skeletal Development of the Hand and Wrist. This was later improved in their second edition (1958). At present, this technique is a very popular method to evaluate skeletal age.

Acheson (1954) applied stages to the morphological changes observed in each bone of the hand and wrist. This method is known as the Oxford Technique. The number of units are totalled and the skeletal age calculated from this sum.

Tanner and Whitehouse (1959) refined the Oxford Technique with more exact mathematical calculations and separate tables for males and females. In this method, each stage of the twenty bones in the hand and wrist has a numerical score which when totalled, results in a maturity score for that particular individual.

There appears to be a sex difference in skeletal maturation: in fact, Tanner (1962), suggests that girls are ahead by a few weeks at birth and by adolescence there is a difference of two years between the sexes in their growth spurts.

There are definite racial and ethnic differences in the rate of maturation. Most racial groups appear to be retarded when compared to the Greulich and Pyle Atlas (Koski et al, 1961; Sutow and Ohwada, 1954; Masse and Hunt, 1963). A possible reason for this could be nutritional deficiencies (Moore, 1969), although the role of genetic or environmental factors in this regard has yet to be partitioned.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The Sample

The sample under investigation consisted of 114 randomly selected Indian children, equally divided by sex, residing on the Peguis Indian Reserve in Manitoba, Canada, as well as control sample comprised of 163 Caucasians, 72 males and 91 females, residing in and around metropolitan Winnipeg. In addition, this study included an acceptable occlusion sample selected from each group.

No attempt was made to subgroup the Indian sample into pure and mixed Indian groups as complete geneologies were unavailable, a reluctance on the part of the Indian Tribe to allow serological studies and the likehood of a genetically pure sample large enough for statistical purposes was remote. Using facial features as well as hair and skin color, obvious hybrids and non-Indians were eliminated from the sample as there has been no genetic study as yet to identify their homo- or heterogenicity. The results should be considered as representative of the Indian child living on the Peguis Indian Reserve and are not necessarily representative of all Indian children in Manitoba.

The subjects ranged in age from eight to eighteen years and they were subgrouped into the following age groups: 8-11 years, 12-13 years and 14-18 years. These cross-sectional age groups are supposed to represent the mixed dentition, adolescent dentition and the dentition of young adults respectively.

As previously mentioned, an acceptable occlusion sample comprised of 31 Indian School children was selected from the 114 Indian children. This sample was used to determine cephalometric treatment standards for this particular Indian group. The criteria used for an acceptable occlusion were:

1. All permanent teeth present except 3rd molars.
2. Angle Class I molar relationship (mesial buccal cusp of the maxillary first permanent molar occluding in the buccal groove of the lower first molar) when in centric occlusion.
3. No clinically observable asymmetry in either dental arch.
4. Overjet no more than 4 mm and overbite no more than 50 percent.
5. Adjacent teeth in contact or with diastemas not in excess of 1 mm.
6. No axial rotations in the dental arch of clinical significance (10-15°).
7. No displacement of any tooth exceeding 2 mm in a labial or lingual direction and 4-5 mm in a mesial or distal direction.
8. No previous orthodontic treatment.
9. No clinically detected or reported functional temporomandibular joint disorders.
10. Resided all their lives on the Peguis Reserve.

For the purpose of comparison, a randomly selected control sample similar to the Indian sample in age range and sex was collected, as well as an acceptable occlusion control sample which had been selected earlier from various Winnipeg schools (Banack, 1972) was utilized. The age and sex distribution of the Indian and control sample is found in Table 1.

The records obtained for each subject included a lateral cephalometric radiograph (Figure 3) and a hand-wrist radiograph (Figure 4).

Cephalometric Technique

The lateral cephalometric radiographs were taken using the conventional technique first pioneered by Broadbent (1931). The subject's head was positioned in the cephalostat so that the central beam of the x-ray passed through the ear rods parallel to the trans-meatal axis and at right angles to the midsagittal plane of the head. The radiographs were taken with the teeth in centric occlusion or maximal occlusal interdigitation and the Frankfort horizontal plane parallel to the floor. The anode to midsagittal plane distance was five feet (152.4 cm) and the midsagittal plane to film distance was 15 cm. This procedure insured uniform magnification of all mid-sagittal structures and made possible the use of a common correction factor for each group.

Two cephalometric machines were used in this study. The Indian sample was collected using a portable cephalometric machine constructed by the author. This machine was built along the lines of

Table 1

SUMMARY OF SAMPLE SIZE

RANDOMLY SELECTED GROUP						
Age Group in Years	INDIAN			CONTROL		
	Male	Female	Total	Male	Female	Total
8 – 11	18	29	47	26	31	57
12 – 13	25	18	43	23	33	56
14 – 18	14	10	24	23	27	50
TOTAL	57	57	114	72	91	163

ACCEPTABLE OCCLUSION GROUP						
Age Group in Years	INDIAN			CONTROL		
	Male	Female	Total	Male	Female	Total
11 – 14	16	15	31	17	26	43

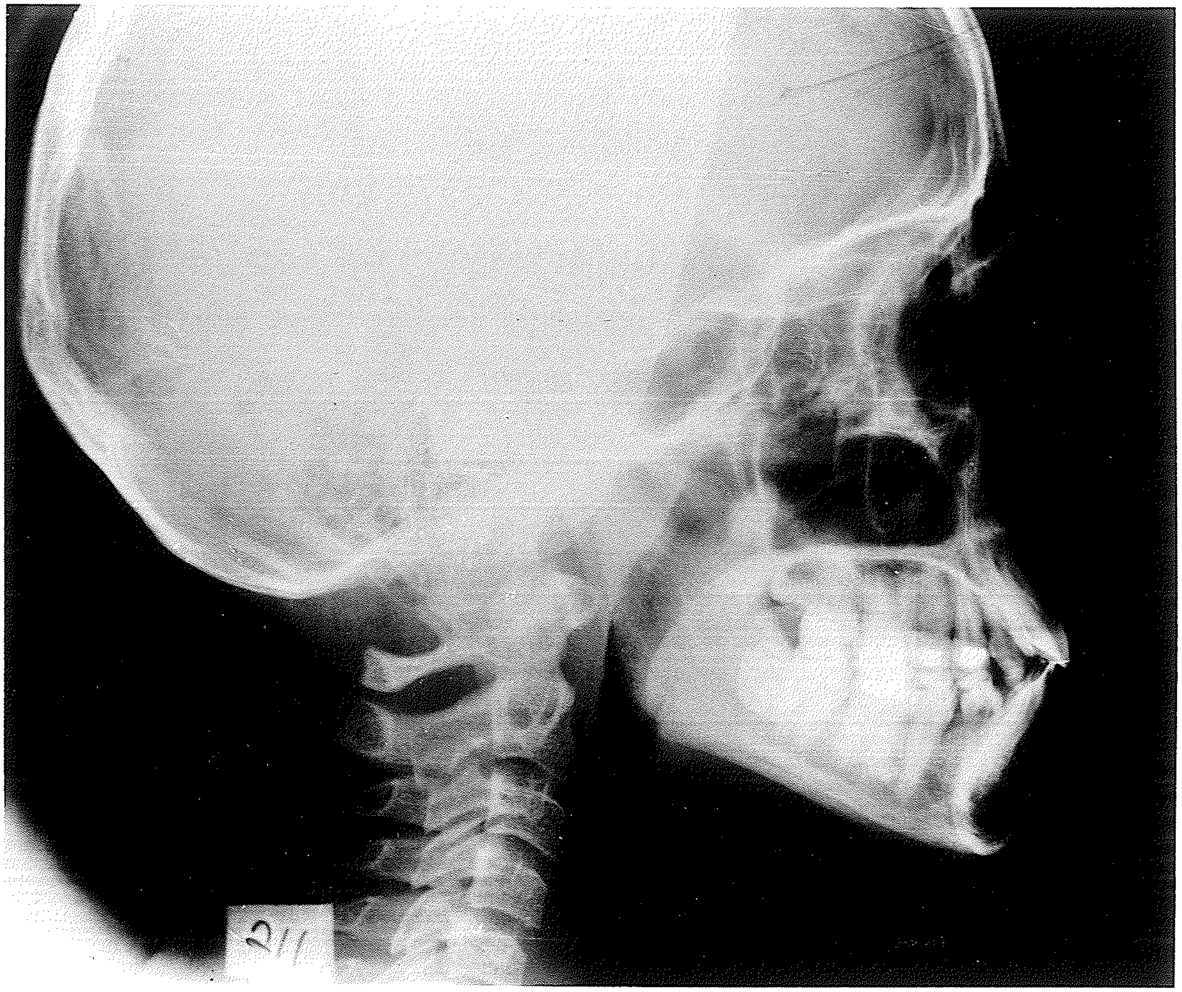


Figure 3. Lateral cephalometric radiograph of an Indian child aged 14 years 11 months.

Figure 4. Hand wrist radiograph of an Indian child with a chronologic age of 11 years 5 months.

a conventional cephalometer utilizing a General Electric* 90 KV x-ray head and control panel, a cephalostat and a plywood base which could be easily dismantled for transportation (Figure 5). A Cephalometrix** cephalometer in the University of Manitoba Orthodontic Department was used on all the control group (Figure 6).

Magnification for these two machines with fixed focal length and midsagittal to film distance described above, was determined by the author. The magnification was decided by projecting a metal gauge of known length in the midsagittal plane onto the radiographic films. Magnification for the portable cephalometer and for the cephalometrix cephalometer were found to be 8 percent and 9 percent respectively. The coordinates were corrected for magnification prior to the calculations to allow simplification of computer programming for all linear and angular measurements. All linear dimensions were thus corrected for magnification to absolute units which allowed direct comparisons of linear measurements between the two samples. Angular measurements were not affected by magnification.

* General Electric of Canada Ltd, Toronto, Ontario

** Moss Corporation, Chicago, Illinois.

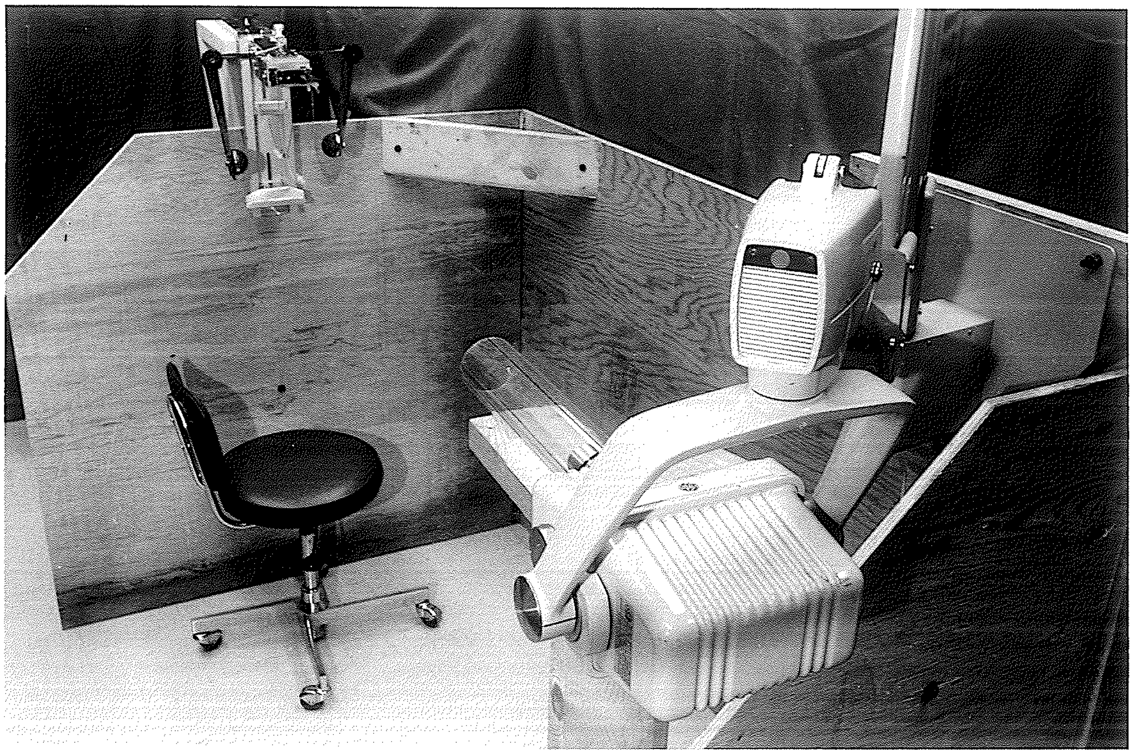


Figure 5. Portable cephalometer.

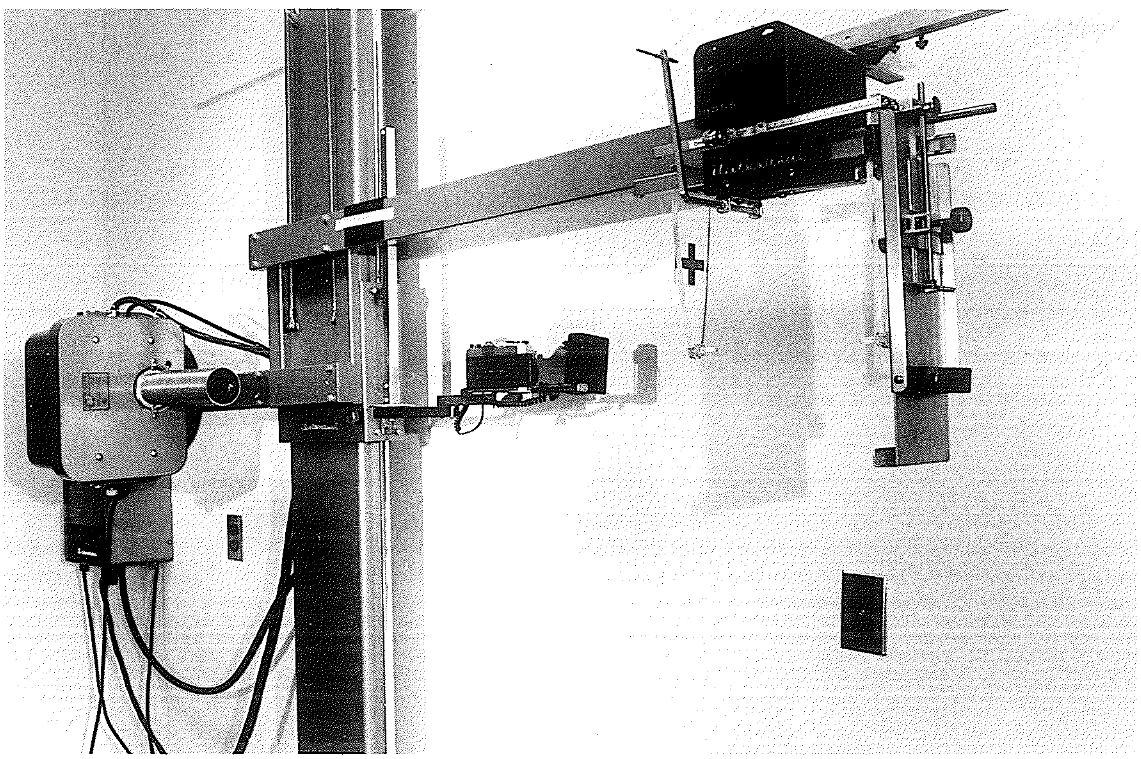


Figure 6. Moss Cephalometrix cephalometer.

Assessment of Skeletal Development

A portable hand-wrist-x-ray machine (Figure 7) was used to radiograph the left hand and wrist following the technique described by Tanner and Whitehouse (1959). The left hand was placed in contact with the film, with the palm facing downwards and the axis of the middle finger in direct line with the axis of the forearm. The fingers were spread slightly while the thumb was placed in a comfortable natural position with its axis making an angle of about 30^{o} with the first finger. Using a phantom hand supplied by the Radiation Protection Branch, the x-rays were tested for clarity and repeatability. The above mentioned technique was found to be repeatable and all x-rays were of an adequate standard for analysis. The tube of the x-ray machine was centered above the head of the third metacarpal with a tube-film distance of 30 inches (76 cm). The machine was set at 10ma and 65 KV with the exposure time varying from 0.25 to 0.50 seconds, depending on the age of the subject and the size of the hand.

The skeletal development was assessed by the Oxford method (Tanner and Whitehouse, 1959). This method was chosen because of its reliability (Johnston, 1963) and applicability to all ethnic groups (Tanner, 1975). Johnston (1963) and Acheson (1966) using duplicate assessments by a single observer, found less variation in the skeletal age, utilizing the Tanner-Whitehouse method as compared to the Greulich-Pyle method of assessment.

Using the Oxford Scoring system (Tanner and Whitehouse, 1975)

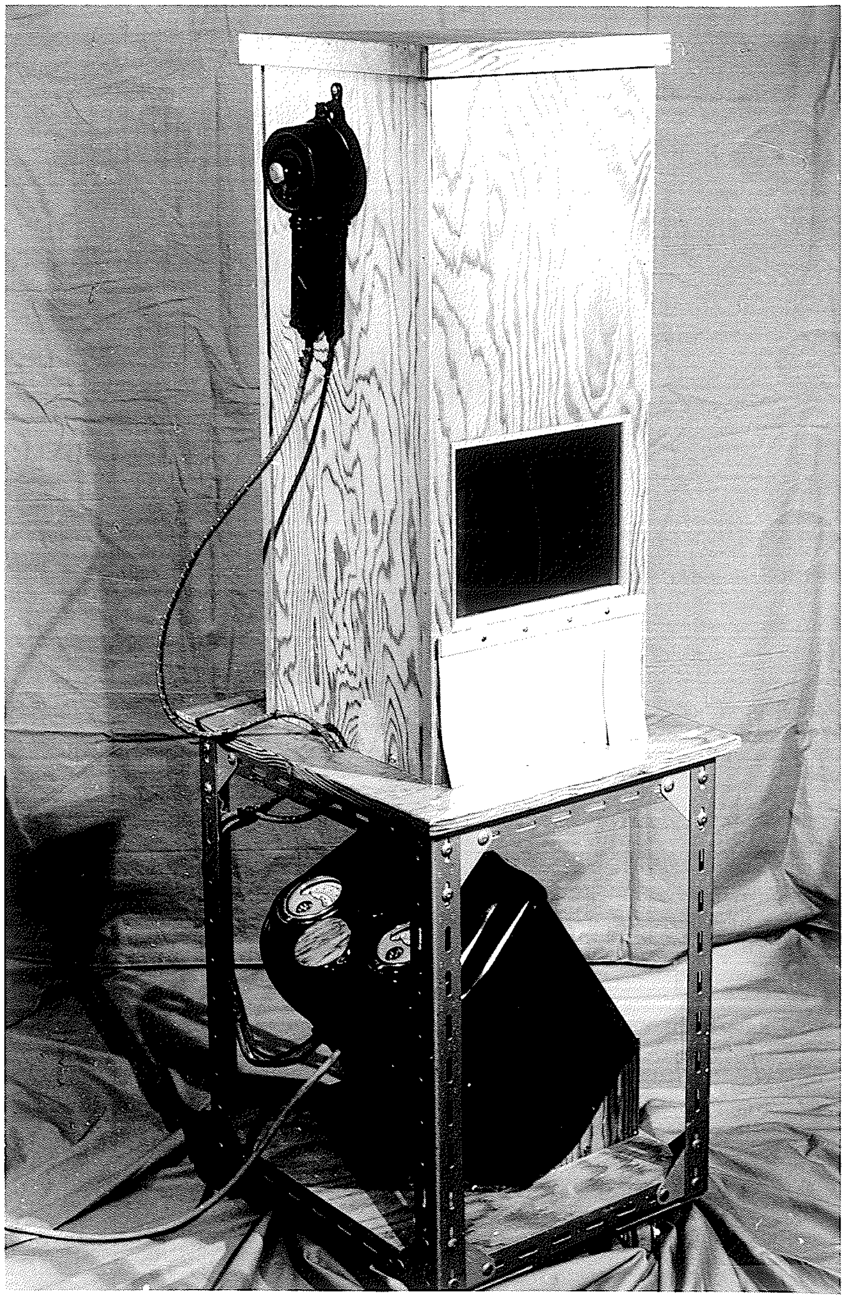


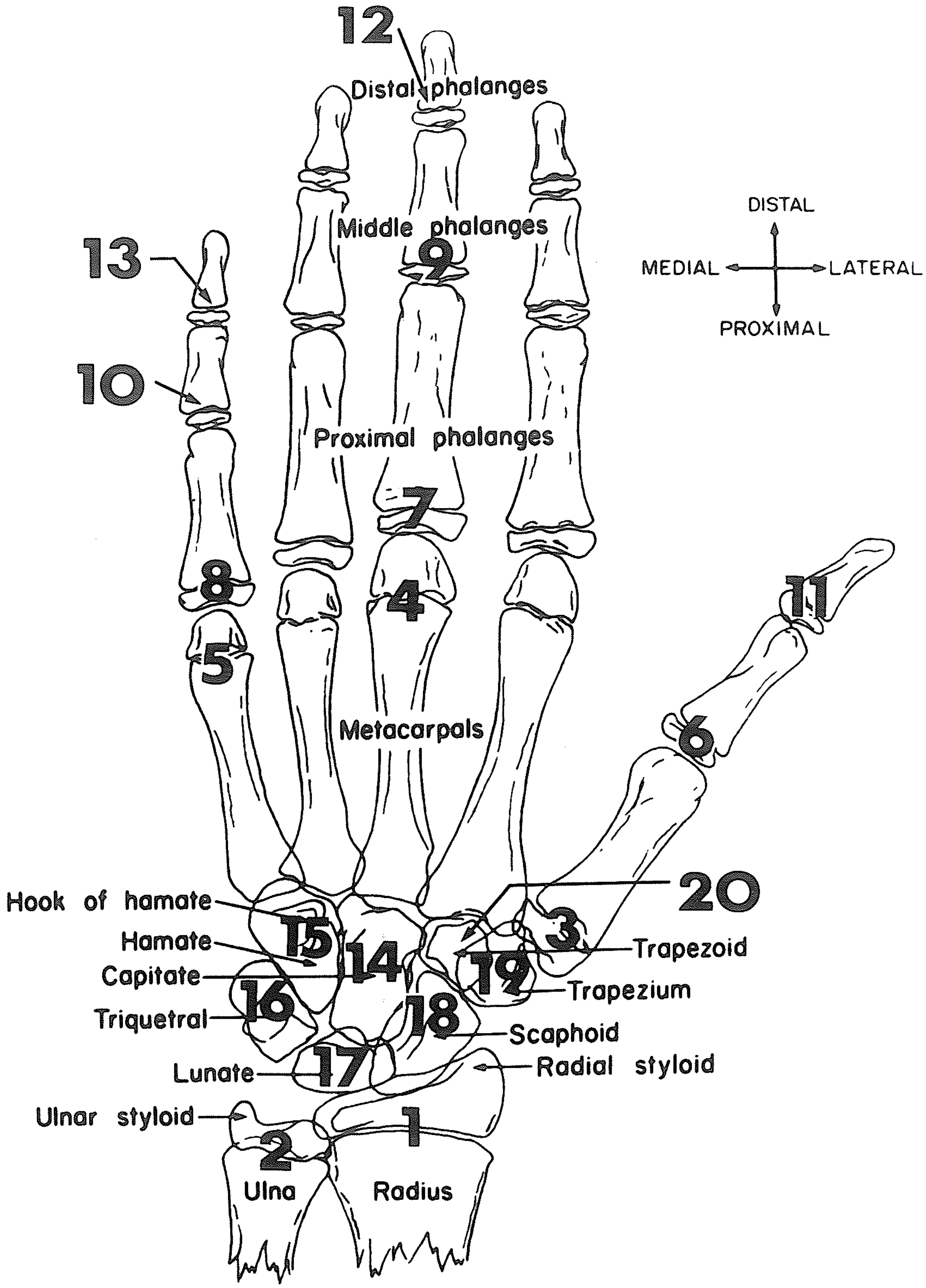
Figure 7. Portable hand-wrist x-ray machine (Nevile, 1973).

evaluations for each bone are assigned by comparing the bone in question with diagram and descriptions which accompany each stage of development. The stages ranged from not visible to fully mature for each bone evaluated, with associated values for each stage. These values as well as the criteria for placing a specific bone in a particular stage are found in appropriate tables. If one of the described criteria is required, then it must be present, if two criteria are required to classify, then two must be present to satisfy the requirements of this stage. The numerical scores of the twenty bones (Figure 8) are then totalled. The total scores may range from zero to one thousand. A prediction table may then be used to find the skeletal age from the total source. Separate tables are used for males and females. Following Tanner's suggestion, all radiographs were read with the fingers pointing away from the observer and the thumb to the right side of the viewer (Figure 4).

Plotting Cephalometric Landmarks

A total of 33 landmarks, previously described by Cleall and Chebib (1971) were selected to be digitized from the radiographs of the Indian and control groups. These landmarks are illustrated in Figure 9. A detailed description of the landmarks is found in Appendix I. All bilateral images of paired landmarks were midplaned thereby effectively reducing lateral landmarks to the same value as midsagittal structures. When a landmark was missing or could not be identified, it was omitted for the subject. Since one particular

Figure 8. Bones of the left hand and wrist (after Tanner, 1975).


12
Distal phalanges
Middle phalanges
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Proximal phalanges
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Metacarpals
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MEDIAL
LATERAL
PROXIMAL
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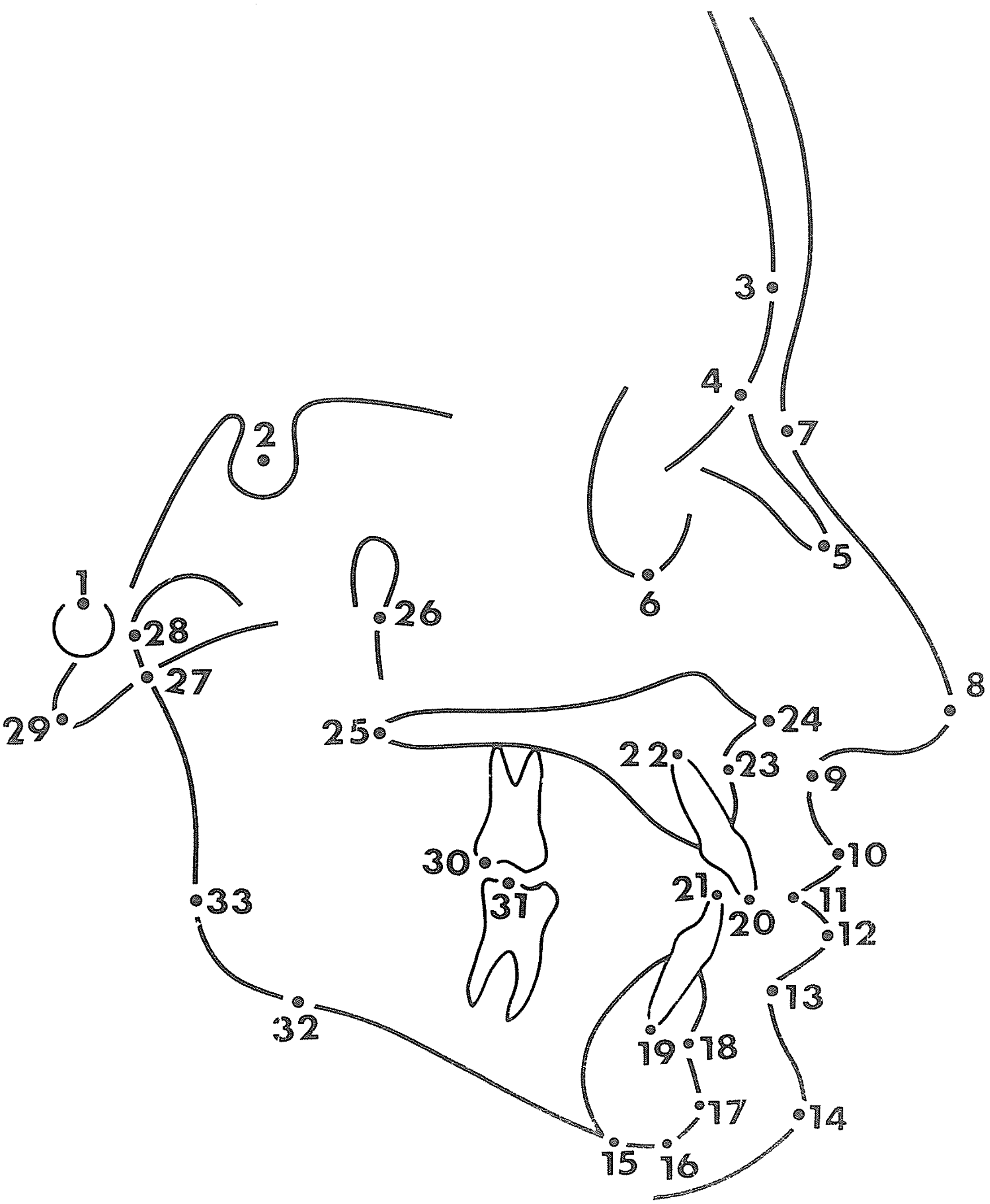
Hook of hamate
15
3
Hamate
Trapezoid
14
Capitate
19
Trapezium
16
Triquetral
18
Scaphoid
17
Lunate
Radial styloid
Ulnar styloid
1
2
Ulna
Radius

Figure 9. Craniofacial landmarks selected for this study.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landmark was not found to be unidentifiable more often than any other, it was felt that all data points would be of equal significance.

The "X" and "Y" coordinates of each landmark were digitized from the radiograph in a preselected sequence (Figure 9) and recorded directly onto 80 column punch cards* by means of a Ruscom* logistics strip chart digitizer (Figure 10). Information from the punch cards was then analyzed by the University of Manitoba IBM 370-68 computer by the use of the cephalometric coordinate analysis computer program developed at the Department of Preventive Dental Science (Chebib, 1977).

Despite precautions, the cephalometric radiographs could have been taken at varying head orientations and elevations. Therefore, they were transposed to a standard orientation using the technique described by Cleall and Chebib (1971). This involved the transformation of each radiograph to a common set of axes defined by a point of origin (Sella) and a direction (Nasion). All the linear and angular measurements were then computed according to the now traditional method of coordinate analysis described by Cleall and Chebib (1971). The deviation of each point from the appropriate sample mean was used to check the raw coordinate data for possible digitizing errors.

* IBM, Don Mills, Ontario, Canada

** Ruscom Logics Limited, Rexdale, Ontario, Canada.

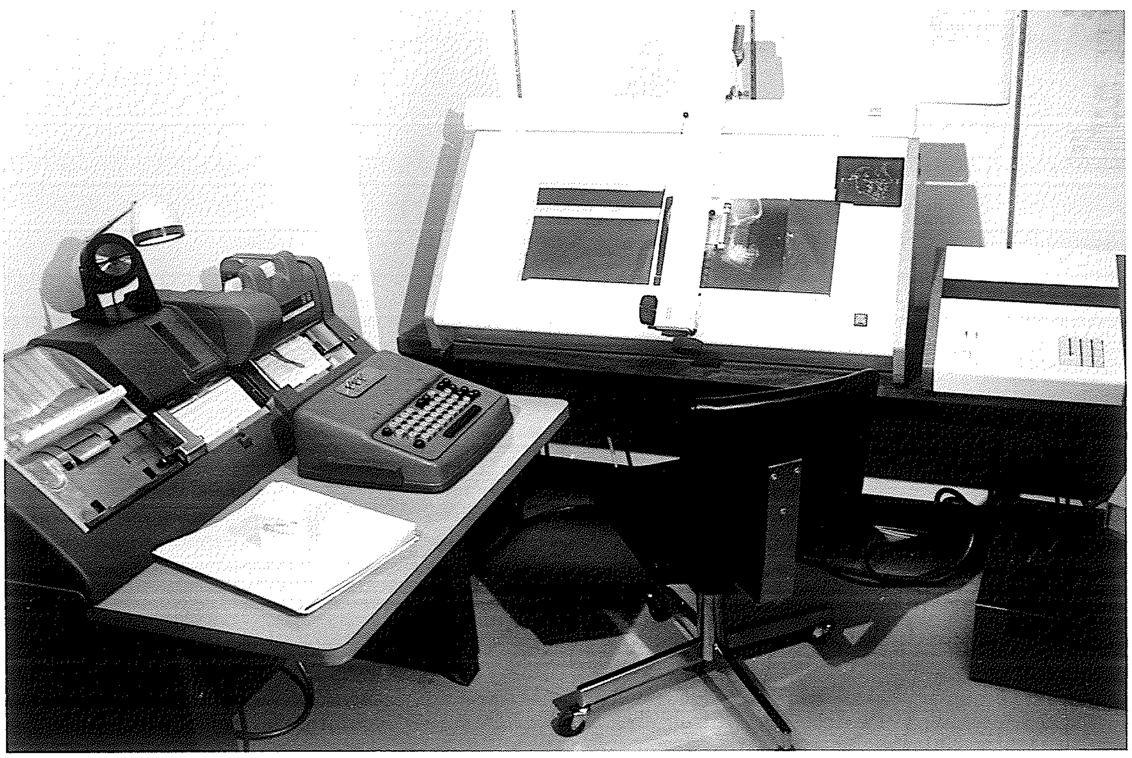

Figure 10. IBM key punch connected to the Ruscom logistics strip chart digitizer.

Error of the Measurement

To determine the accuracy of the identification of the various landmarks used in the study and the repeatability of the coordinate measurements, the X and Y coordinates for the landmarks of 15 randomly selected radiographs were digitized in duplicate. A total of 13 angular and linear cephalometric measurements per radiograph were calculated to estimate the error of the measurement as devised by Chebib and Burdick (1973).

This estimation of the error included the calculation of the standard deviation of measurement error(s), the expected mean error ($\bar{e}$) and the maximum error (e_p) associated with 99 percent of the values. The formulas for the above calculations are:

1. $$s = \sqrt{\frac{\varepsilon\ [\varepsilon\ (x-\bar{x})^2]}{\varepsilon\ (n-1)}},\quad df = \varepsilon\ (n-1)$$

2. $$\bar{e} = \pm\sqrt{\frac{2}{\pi}}\quad s = .7979s$$

3. $$e_p = \pm\ t\ (99\%,\ df)\ .s$$

where t = the theoretical student t value for df (degrees of freedom) associated with s and the probability p (99%).

The variables for the error of the measurement and accuracy of the point selection are found in Table II. The results seen in the 99 percent maximum error column is the maximum error

TABLE II

Expected Mean Error ($\bar{e}$), Standard Deviation of Measurement Error(s), 99% Maximum Error for 13 Cephalometric Variables.

Variable	Mean Error ($\bar{e}$)	Standard Deviation of Error(s)	99% Maximum Error ($\pm$)
Facial Angle	.442	.554	1.63^{o}
Angle of Convexity	0.9569	.7629	2.82^{o}
SNA	.606	.759	2.24^{o}
SNB	.467	.585	1.73^{o}
ANB	.470	.589	1.74^{o}
Frankfort Mandibular Plane Angle	.646	.809	2.39^{o}
Interincisal Angle	1.468	1.840	5.42^{o}
UI to SN	1.221	1.531	4.51^{o}
LI to Mandibular Plane	.839	1.051	3.09^{o}
UI to AP	.261	.327	.97 mm
LI to AP	.286	.359	1.06 mm
LI to NB	.255	.319	.94 mm
P to NB	.233	.293	.86 mm

expected for that particular variable 99 percent of the time.

The maximum error for angular measurements ranged between 5.4° for the interincisal angle and 1.6° for the facial angle, while the maximum error for linear measurements was between 1.05 mm (LI and AP) and .86 mm (p to NB). The difficulty in identifying incisor apices (especially the apex of the mandibular incisor) was most likely responsible for the high angular measurements error.

Cephalometric Analysis

The measurements selected for this study were determined by reviewing the literature and choosing the cephalometric variables that were felt to adequately define the craniofacial complex. A total of 44 linear and 28 angular measurements were used in this study. A list of the linear and angular measurements, (Figures 11-19) used to assess the dentofacial aspects of the North American Indian and Winnipeg Caucasian is found in Appendix II.

Figure 11. Illustration of the linear measurements obtained from the lateral cephalogram.

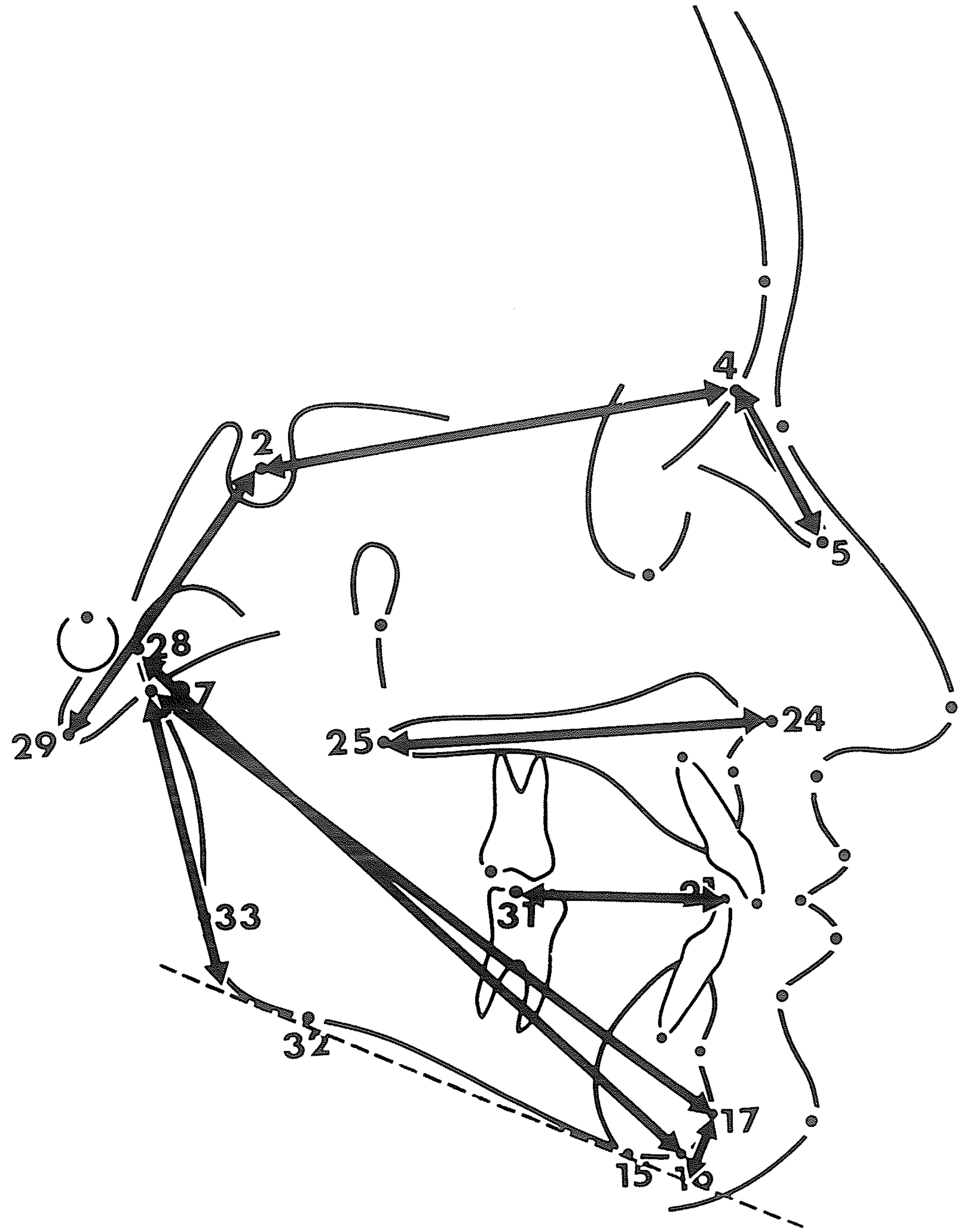
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Figure 12. Illustration of the linear measurements obtained from the lateral cephalogram.

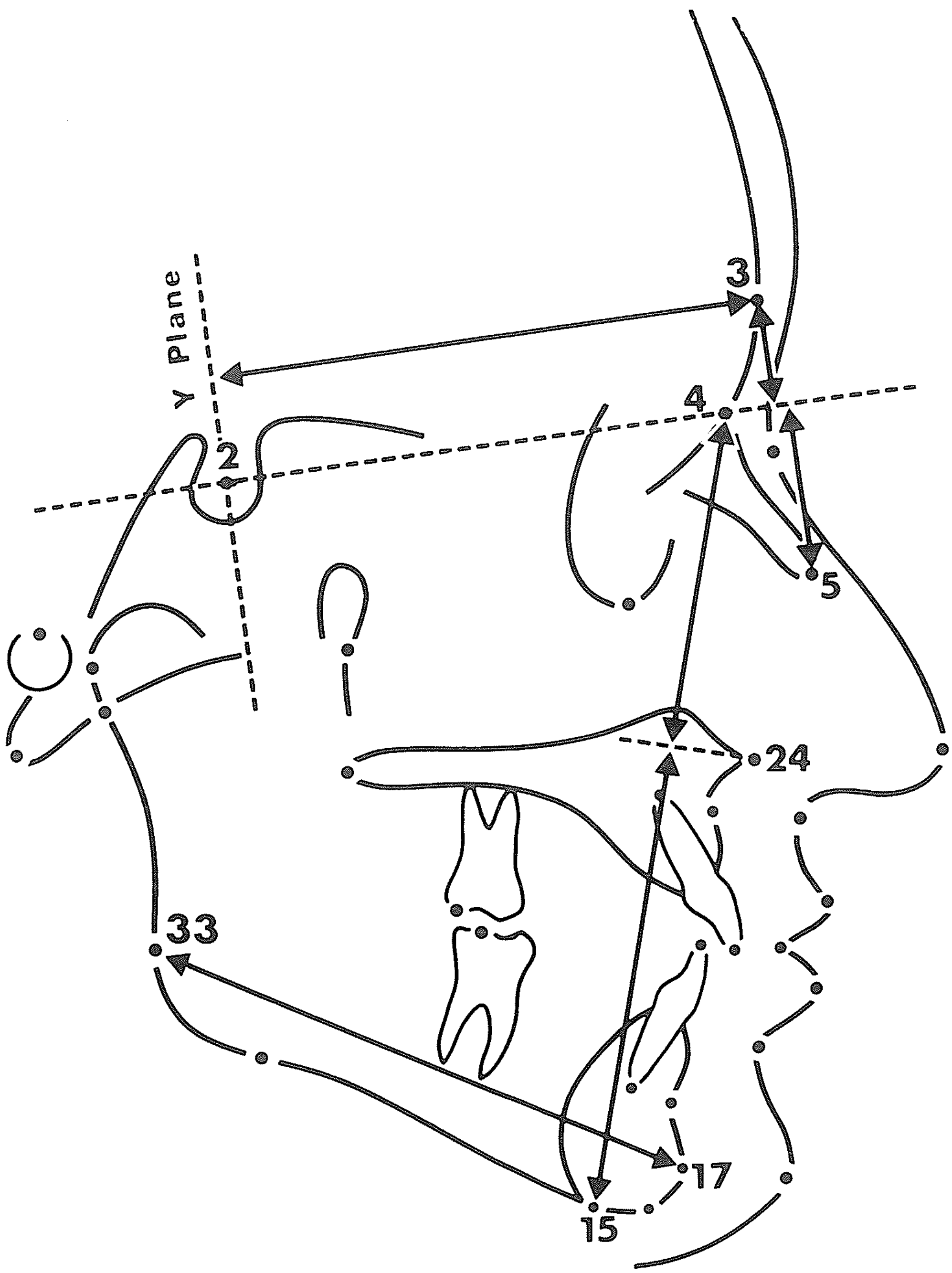
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Figure 13. Illustration of the linear measurements obtained from the lateral cephalogram.

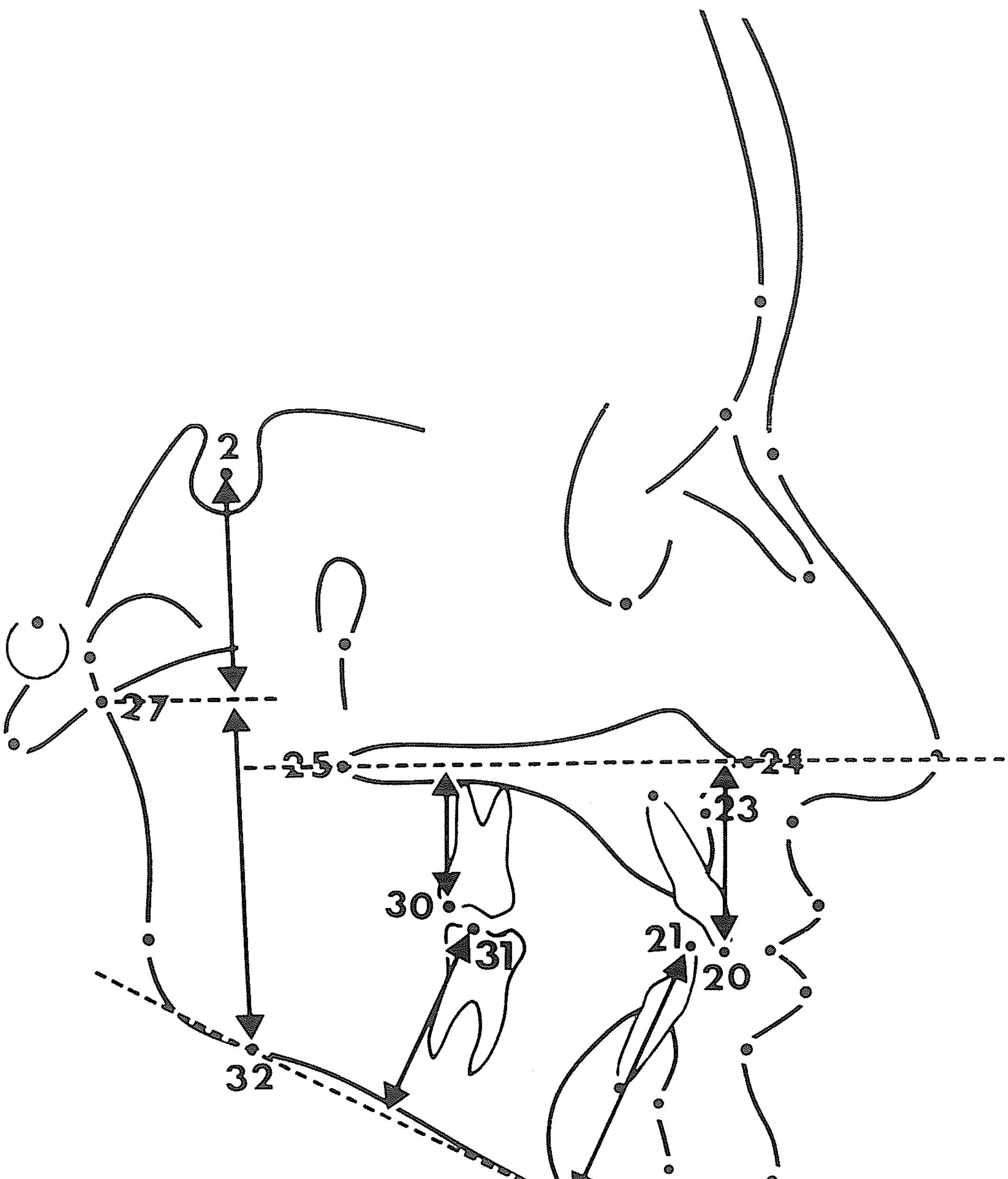
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Figure 14. Illustration of the linear measurements obtained from the lateral cephalogram.

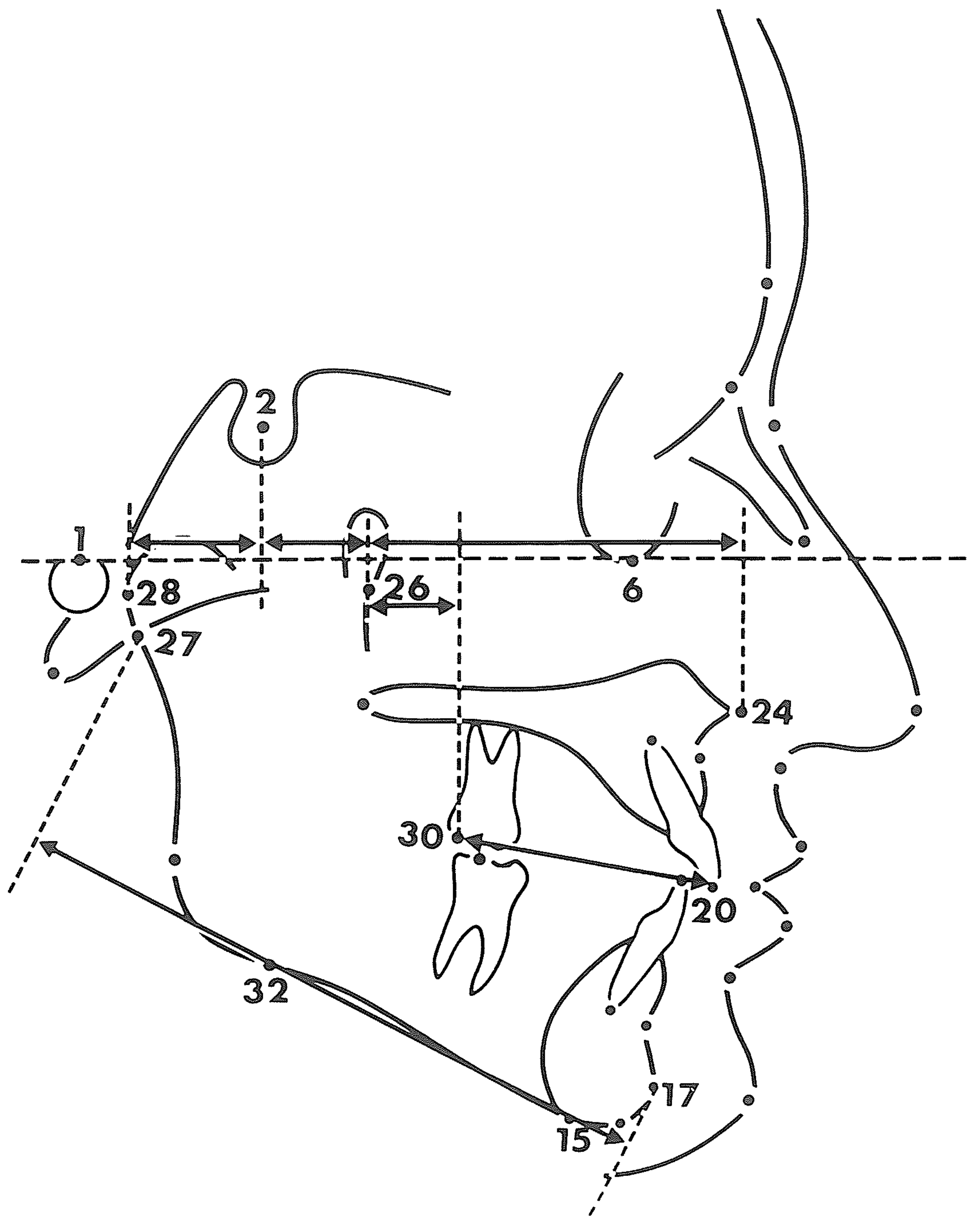
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Figure 15. Illustration of the soft tissue linear measurements obtained from the lateral cephalogram.

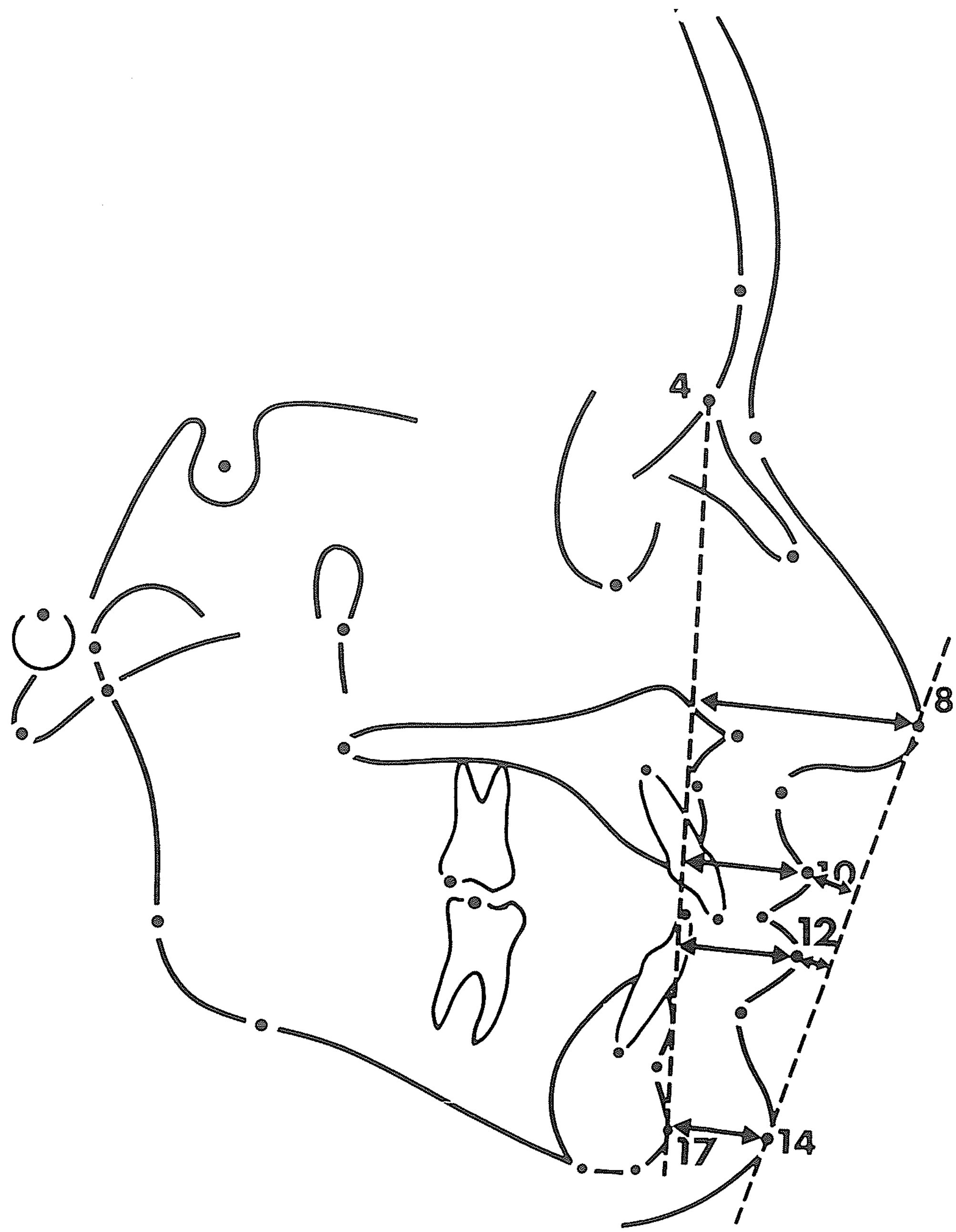
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Figure 16. Illustration of the angular measurements obtained from the lateral cephalogram.

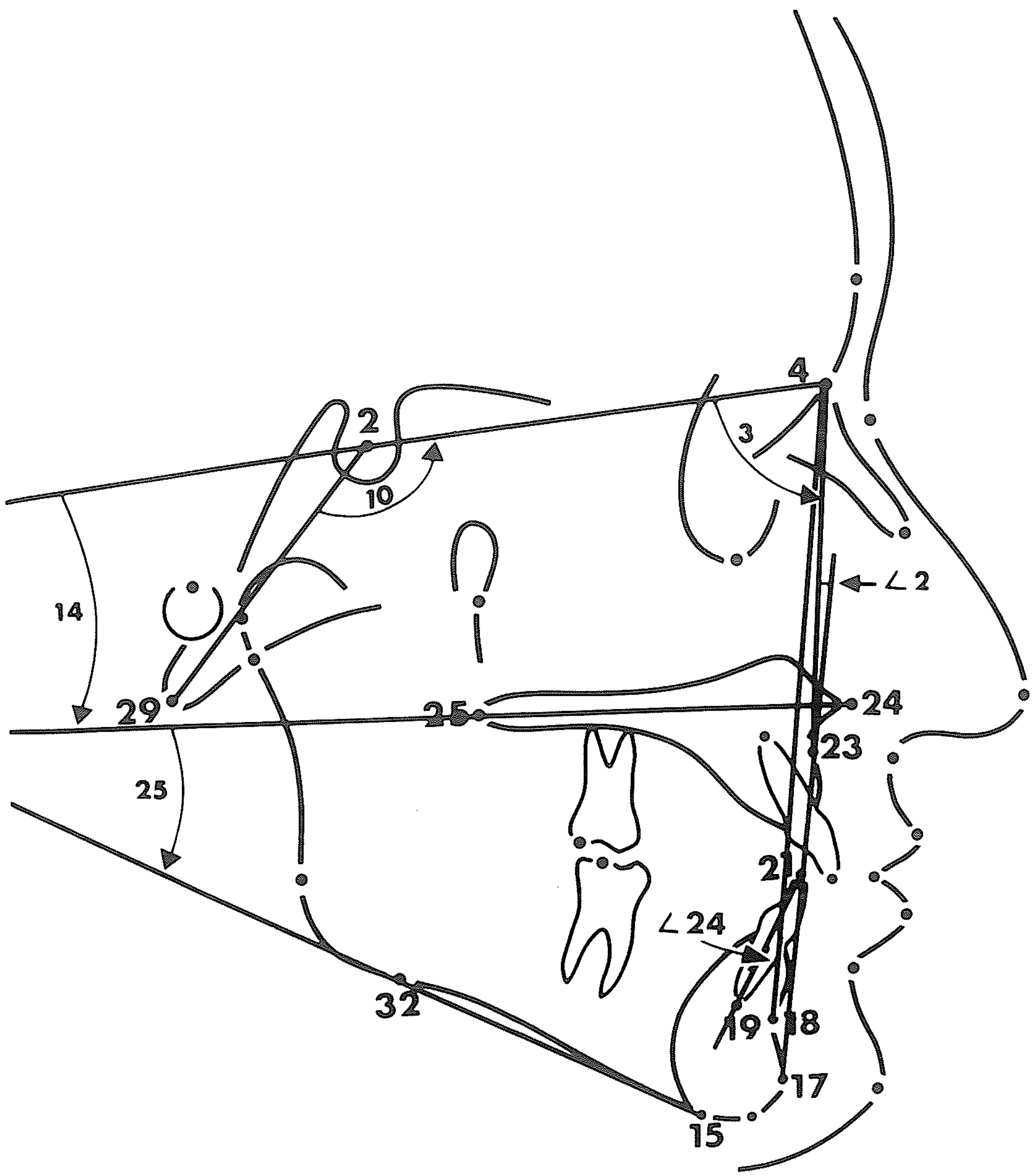

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Figure 17. Illustration of the angular measurements obtained from the lateral cephalogram.

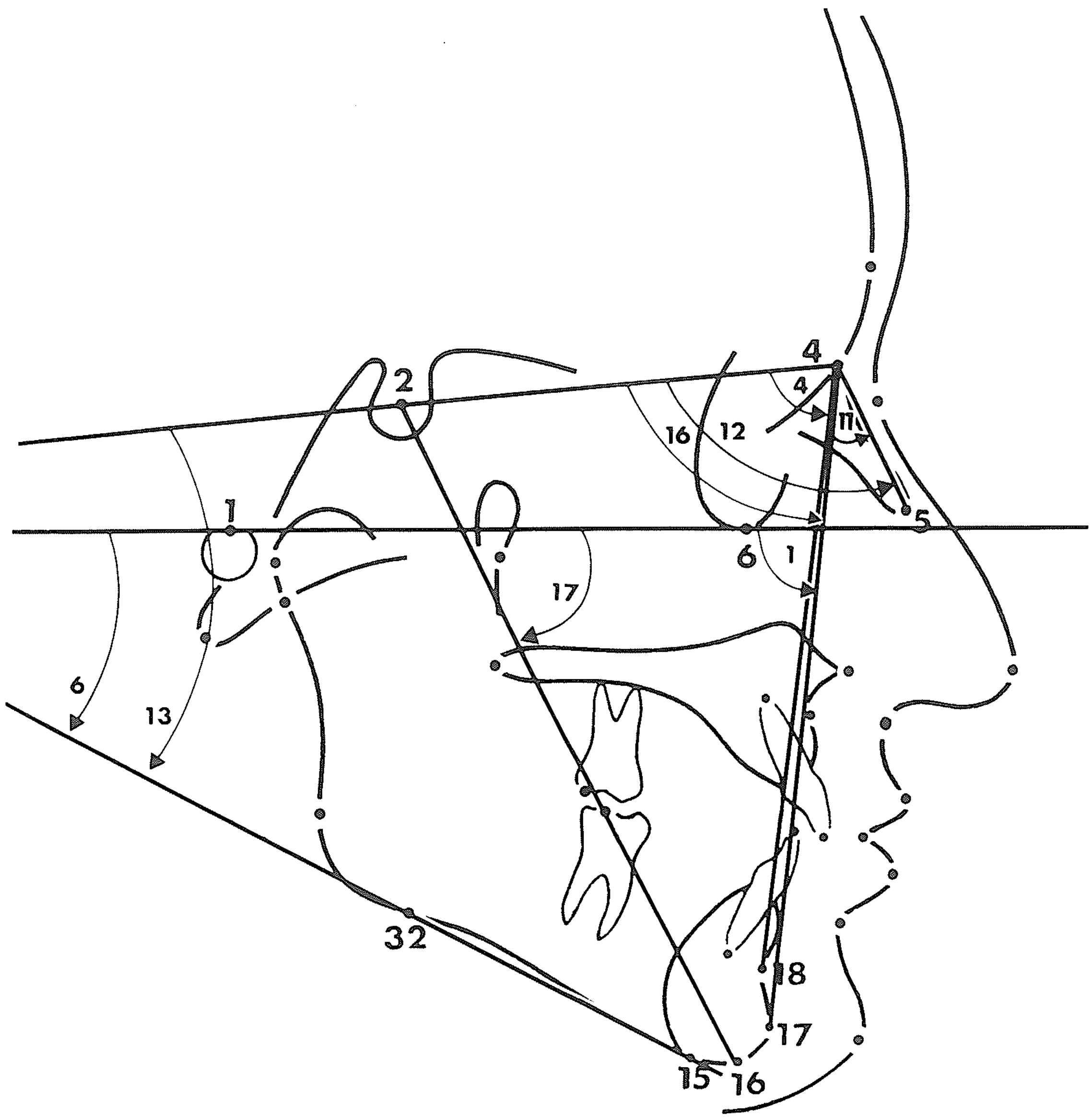
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Figure 18. Illustration of the angular measurements obtained from the lateral cephalogram.

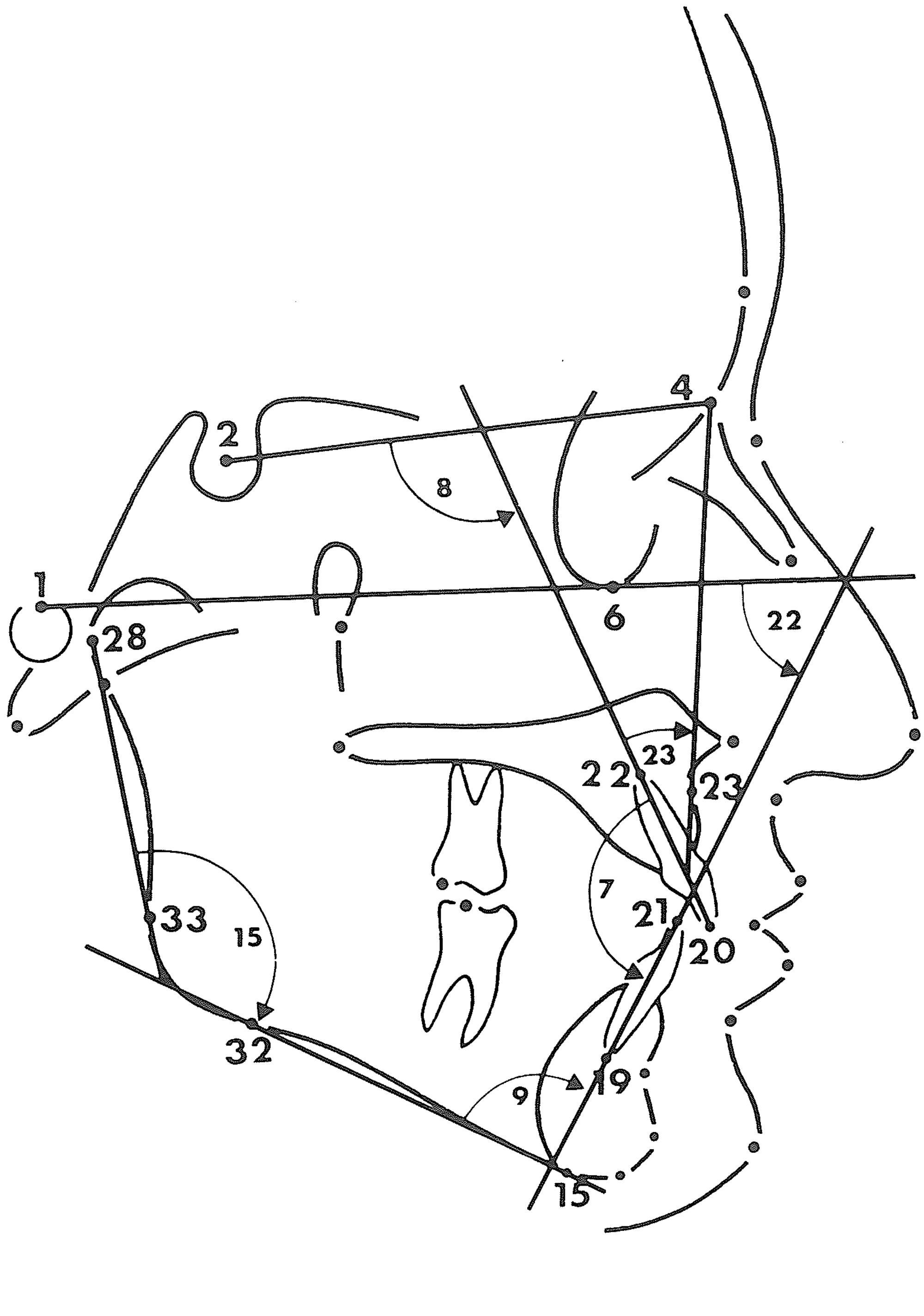

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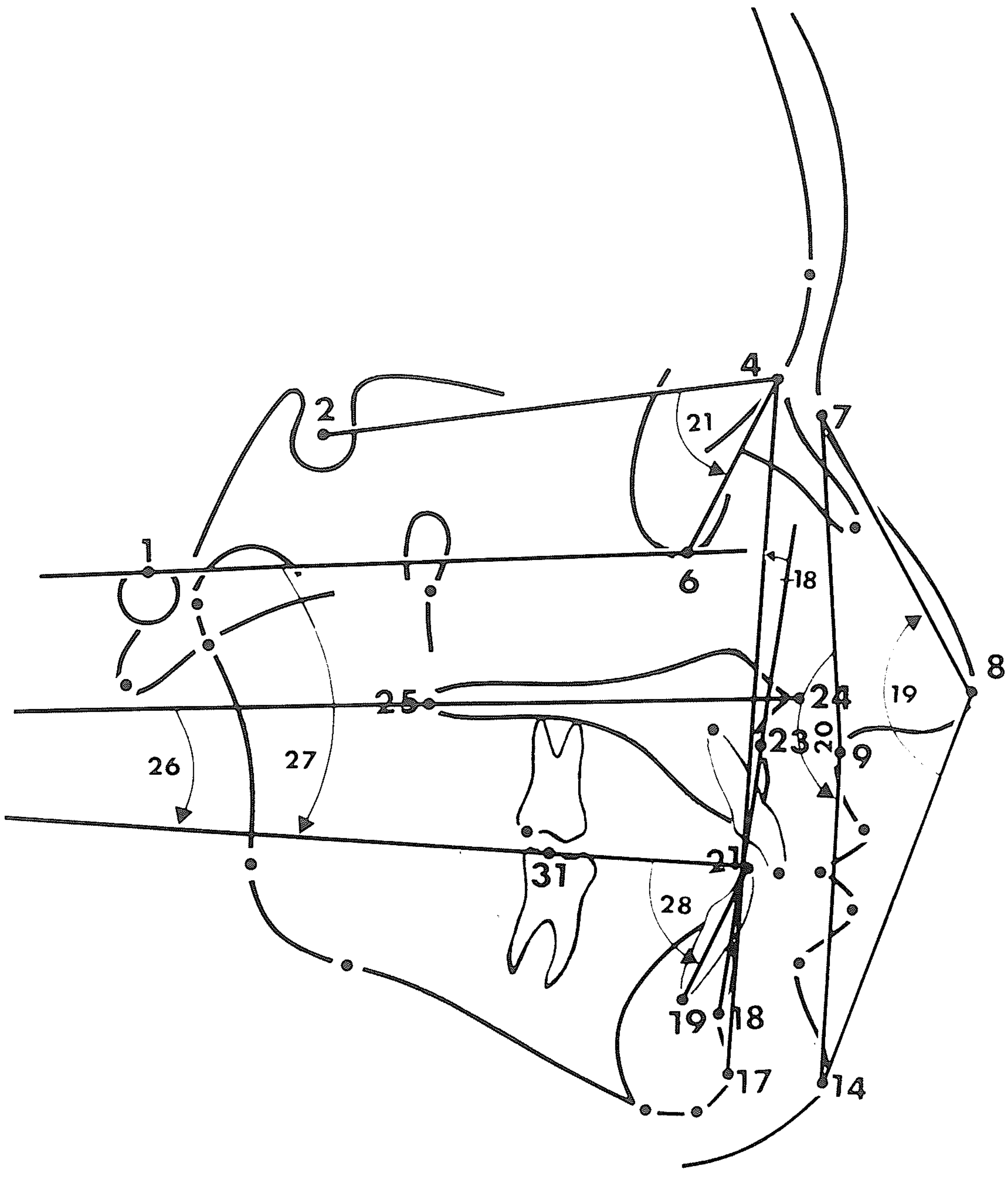
Figure 19. Illustration of the angular measurements obtained from the lateral cephalogram.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Statistical Analysis of the Data

a) Univariate Analysis

Means, standard deviations and standard errors were computed for each of the 44 linear and 28 angular measurements according to group, sex and age, and each variable was then analyzed independently as a 3-factor factorial experiment with unequal N's. The factors were: group at two levels (Indian and Control), sex at two levels (male and female) and age at 3 levels (8-11, 12-13 and 14-18). The 276 degrees of freedom between the 277 subjects were allocated as shown in Table III. All main effects and interactions were calculated and tested for significance.

b) Discriminant Function Analysis

The analysis of variance results were used in selecting a smaller number of variables for a discriminant function analysis. Those that displayed a significance level of 5 percent or less between the Indian and Control groups were selected (17 linear and 11 angular) as described by Huberty (1975). The objective was to determine the difference between these two groups, therefore, a stepwise discriminant function analysis was performed using the BMDP program number P7M at the University of Manitoba. This analysis is a multiple discriminant analysis done in a step-wise manner (Dixon, 1975). At each step one variable is entered into the set of discriminating variables. The variables entered in step 1 are the variables that the program has found best able to separate between the groups being analyzed, based on group comparisons of mean values (Stevens, 1973).

Table III. Degrees of Freedom for the Sources of Variation for the 277 Subjects.

Source of Variation	Degrees of Freedom
Between Groups	1
Between Sexes	1
Among Age Groups	2
Group × Sex	1
Group × Age	2
Sex × Age	2
Group Sex Age	2
Within Cells	265
TOTAL	276

The remaining variables are then reconsidered and the second variable selected is the variable that adds the most to the first variable's discriminating ability. This process was continued until the entering of new variables no longer added significant separating ability to the set of discriminating variables.

The seventeen linear and eleven angular variables that were obtained from the univariate analysis were subjected to a stepwise discriminant function analysis to identify the most discrimimating variables between the two groups (Indian and Control). In addition, the stepwise discriminate analysis was repeated for each sex separately, as well as for each of the three age groups.

c) Cephalometric "Norms"

In the determination of cephalometric "norms" for the acceptable occlusion group, the means and standard deviations for all variables covering the standard cephalometric analysis (Downs, 1948; Holdaway, 1956; Manitoba, 1973; Riedel, 1952; Tweed, 1944, 1954; Wylie, 1947), were calculated and reported.

d) Growth Trends

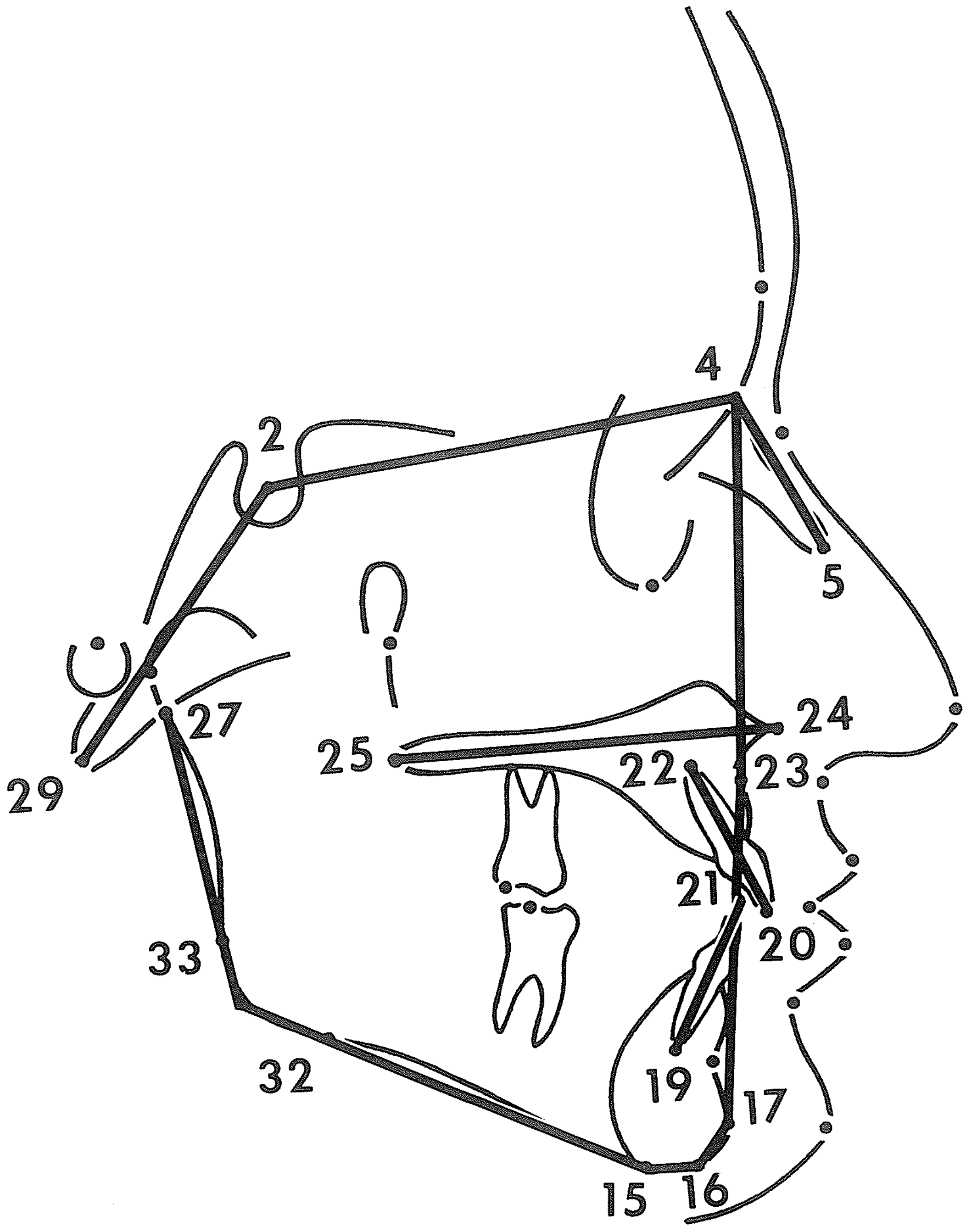
In order to assess age changes or growth trends, 40 variables (found in Appendix III) were selected. Some were selected as they are commonly used reference angles or distances, others were selected on the basis of analyzing dimensional changes in those parts of the craniofacial complex felt to be incompletely examined using the more familiar reference angles and distance. For the purpose of presenting the growth trends, the variables have been divided into six morphological units; cranial base, nasal complex, maxillary complex, mandible, bony profile, soft tissue profile and two linear dimensions, cranial length and facial height. The variables were used to assess the differences and similarities between the Indian and Control group as age increased. The significant differences were presented along with graphs for clarity.

e) Polygonal Profiles

For visual non-quantitative comparisons, mean coordinates obtained from the digitized data were used to construct facial polygons using a specially designed computer plotting program*, comparing the growth and development of the craniofacial complex of the Indian and Control groups, at each of the three age ranges studied. The polygon consisted of points 29, 2, 4, 23, 17, 16, 15, 32, 33 and 27 with palatal plane, nasal bone and incisor proclination also represented (Figure 20). The method of comparison is similar to that used by Bjork (1955) and Colby (1972). Growth trends were determined by superimposing the polygons on the line sella-nasion with registration at point sella.

* F.S. Chebib, Biostatistics - Dept. of Preventive Dental Science.

Figure 20. Facial polygon.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RESULTS

CHAPTER IV

RESULTS

This chapter has been divided into four sections corresponding with each objective. These four sections encompass results obtained from the univariate analysis, discriminant function analysis, acceptable occlusion assessment and finally the maturity assessment performed by comparing the skeletal age against the chronologic age.

Univariate Analysis

Linear and angular measurements were used to describe the morphology and evaluate developmental changes occurring in the craniofacial complex of the Indian population under investigation. Detailed tables listing means and standard errors for each of the seventy-two variables studied are presented in Appendix IV, Table XI, for both the Indian and control samples. Mean values for the main effects of Group, Sex and Age are tabulated in Appendix V, Tables XII-XIV.

The levels of significance of the results revealed by the analysis of variance are summarized in Table IV. Inspection of this table reveals that for a number of the variables the main effects of group, sex and age are highly significant.

Of the 44 linear variables studied, significant differences at the 1% level were detected in 29 variables when group

TABLE IV

Levels of Significance Revealed by the Analysis of Variance for the Angular and Linear Measurements

Source of Variation	Between Groups (Indian or Control)	Between Sexes (Male or Female)	Among Ages (3 Age Groups)	Group x Sex	Group x Age	Sex x Age	Group x Sex x Age
Degrees of Freedom	1	1	2	1	2	2	2
1. Max. Pal. Plane	**	*	**	-	-	-	-
2. Nasal Bone	**	-	**	-	*	-	-
3. Mand. Length (27-17)	-	**	**	-	-	-	-
4. Post Cranial Base	**	**	**	-	*	-	-
5. Corpus Length	-	**	**	-	-	*	-
6. Mand. Length (28-16)	**	*	**	-	**	-	-
7. 8 - Facial Plane	-	-	**	-	*	-	-
8. 10 - Facial Plane	**	**	-	-	-	-	-
9. 12 - Facial Plane	**	**	-	-	-	-	-
10. 14 - Facial Plane	**	-	**	-	**	-	-
11. Pog. to Mand. Pl.	**	-	**	-	-	-	-
12. UI to Facial Pl.	**	-	-	*	-	-	**
13. LI to Facial Pl.	-	-	-	-	-	-	-
14. Ant. Cranial Base	-	**	**	-	-	-	-
15. Glab. to Y-Plane	-	**	**	-	*	-	-
16. 5 - SN Plane	**	-	-	-	*	-	-
17. Glab. to SN Plane	**	-	-	-	-	-	**
18. Upper Face Height	-	**	**	-	*	-	-
19. Total Face Height	**	**	**	-	-	-	-
20. Lower Face Height	**	**	**	-	-	-	-
21. Post. Face Height	*	*	**	-	-	**	-
22. Post. U.F.H.	**	**	**	-	**	-	-
23. Post. L.F.H.	-	-	**	-	*	*	-

Table IV (Continued)

Source of Variation	Between Groups (Indian or Control)	Between Sexes (Male or Female)	Among Ages (3 Age Groups)	Group x Sex	Group x Age	Sex x Age	Group x Sex x Age
Degrees of Freedom	1	1	2	1	2	2	2
24. Overjet	**	-	-	-	*	-	-
25. Overbite	**	-	-	-	*	-	-
26. Ramus Length	**	-	**	-	-	-	-
27. UI to AP	**	-	-	*	-	-	**
28. LI to AP	*	-	-	-	*	-	-
29. Max. Dental Arch	**	*	-	-	-	-	-
30. Mand. Dental Arch	**	-	**	-	-	-	-
31. U6 to Pal. Plane	**	-	**	-	*	-	-
32. UI to Pal. Plane	**	-	**	-	-	-	-
33. L6 to Mand. Plane	**	-	**	-	-	*	-
34. LI to Mand. Plane	**	**	**	-	-	-	-
35. L. Lip to "E" Line	**	**	**	-	-	-	-
36. U. Lip to "E" Line	**	**	**	-	-	-	-
37. UI to NA	**	-	-	-	-	-	-
38. LI to NB	-	-	-	-	-	-	-
39. Pogonion to NB	**	-	**	-	-	-	-
40. Mand. Length	**	**	**	-	*	-	-
41. 2 - 28	-	-	**	-	-	-	-
42. 2 - 26	-	*	-	-	-	-	-
43. 26 - 24	-	**	**	-	*	-	-
44. 26 - 30	-	-	**	-	*	-	-
45. Facial Angle	**	-	*	-	-	-	-
46. Angle of Convexity	**	-	-	-	-	-	-
47. SNA	**	-	*	-	-	-	*
48. SNB	*	-	**	-	-	-	-
49. ANB	**	-	-	-	-	-	-

Table IV (Continued)

Source of Variation	Between Groups (Indian or Control)	Between Sexes (Male or Female)	Among Ages (3 Age Groups)	Group x Sex	Group x Age	Sex x Age	Group x Sex x Age
Degrees of Freedom	1	1	2	1	2	2	2
50. Mand. Plane (FH)	*	–	–	–	–	–	–
51. UI to LI	–	–	–	–	–	–	–
52. UI to SN	–	–	–	–	–	–	–
53. LI to MP	**	*	–	–	–	–	–
54. Cranial Base Angle	*	–	–	–	**	–	–
55. 5 - 4 - 17	–	–	**	–	–	–	**
56. 5 - 4 - 2	–	–	**	–	–	–	**
57. Mand. Plane (SN)	**	–	–	–	–	–	–
58. Pal. Plane (SN)	**	–	–	–	–	–	*
59. Gonial Angle	–	–	*	*	–	–	–
60. 2 - 4 - 17	–	–	**	–	–	–	–
61. Y - Axis	**	–	–	*	–	–	–
62. A - B Plane	**	–	–	–	–	–	–
63. 7 - 8 - 14	**	–	–	–	*	*	–
64. 4 - 23 - 17	**	–	–	–	–	**	–
65. 6 - SN Plane	**	–	**	–	–	–	–
66. FMIA	**	–	–	–	–	–	–
67. UINA	–	–	–	–	–	–	–
68. LI to NB	**	–	–	–	*	–	–
69. Pal. Plane to M.P.	**	–	–	–	–	–	–
70. Occ. Pl. to Pal. Pl.	**	–	–	–	–	–	–
71. Occ. Pl. to F.H.	–	–	*	–	–	–	–
72. LI to Occ. Pl.	**	–	–	–	–	–	–

* $p < .05$
** $p < .01$

was compared, 16 variables when sex was considered and in 31 variables when age was compared. Group X sex interaction, significant at the 1% level was not found in any of the linear variables while group x age and age x sex interactions were observed in only three linear variables and one linear variable respectively.

The 28 angular measurements were examined for the main effect of group, which revealed significant differences at the 1% level in 17 variables. No significant differences for the main effect of sex were observed while 5 variables were significant for the main effect of age. Significant interaction between main effects of group, sex or age were generally not significant. Significant third order interactions, group x sex x age were noted in only 5 variables.

For the purpose of presenting the results of the analysis of variance, the 39 variables identified for investigation (Appendix III) were assembled into eight categories. The first two categories included those variables measuring the linear dimension of the cranial length and facial height while the other six included variables describing several morphological units which were the cranial base, nasal region, maxillary complex, mandible, skeletal facial profile and the soft tissue facial profile. These eight categories were thought to contribute to the growth changes occurring in the craniofacial complex. Because of the large volume of data produced, only significant and relevant effects are graphed under their respective headings.

a) Cranial length

The anterior cranial length (variable 15), the perpendicular distance from the height of convexity of the glabellar region to the Y-plane, showed significant differences at the 1% level for the main effects of sex and age. The males were found to have a longer anterior cranial length. Group x age interaction was found to be significant at the 5% level indicating a difference between these two groups in the development of the cranial length at the three age categories. As can be seen in Figure 21 the control group exhibited a shorter cranial length than in the Indian group in both the 8-11 and 12-13 year categories while the control 14-18 year age category exhibited a longer cranial length than the Indian group.

b) Cranial base

Two linear measurements, anterior cranial base (variable 14) and posterior cranial base (variable 4) and one angular measurement, cranial base angle (variable 54) were used to assess changes in the cranial base.

The anterior cranial base measurement was found to be slightly larger but not significantly different in the control group when compared to the Indian group. This variable increased in length with age ($p < 0.01$). In addition the males were found to have a consistantly larger anterior cranial base length than the females ($p < 0.01$), (Figure 22).

The posterior cranial base measurement showed a significant difference at the 1% level for group, sex and age. The Indian group was larger than the control group, while the males in each group were found to be larger than the females. A group x age interaction was noted ($p < 0.05$) which may suggest the developmental differences of the Indian group and the control group at the different ages as seen in Figure 23. However, the differences which occurred between the 12-13 year and 14-18 year age group may be due to the cross-sectional nature of the sample.

Changes in the cranial base angle demonstrated a change in the spacial relationship of the component parts of the cranial base. These changes may be the result of growth at the terminal ends or flexure of the cranial base. A significant difference at the 5% level was observed with the Indians revealing a more acute cranial base angle than the Caucasians.

Examination of the cranial base variables indicated that the length of the anterior cranial base was smaller in the Indian group than in the control group, while the length of the posterior cranial base was larger in the Indian group.

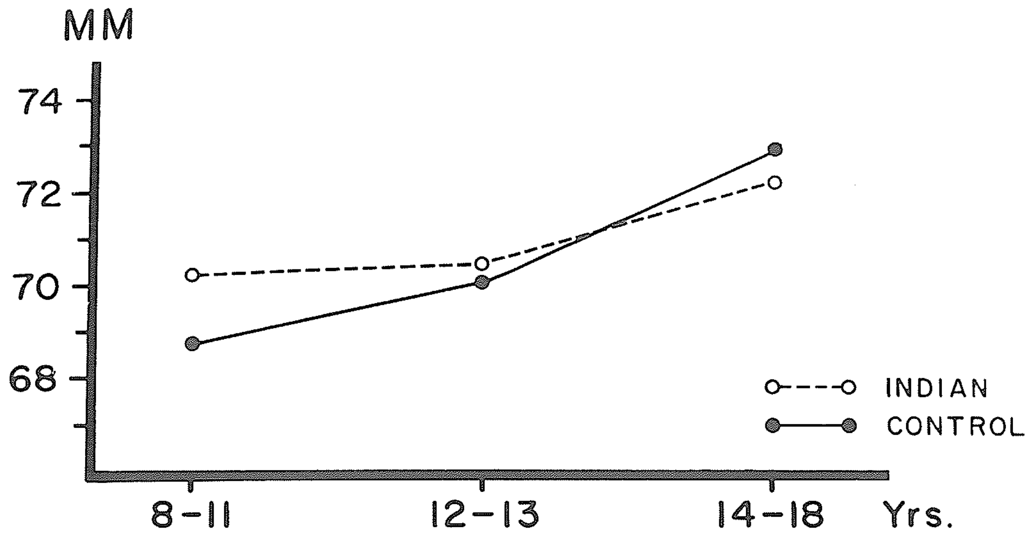
c) <u>Facial Height Measurements</u>

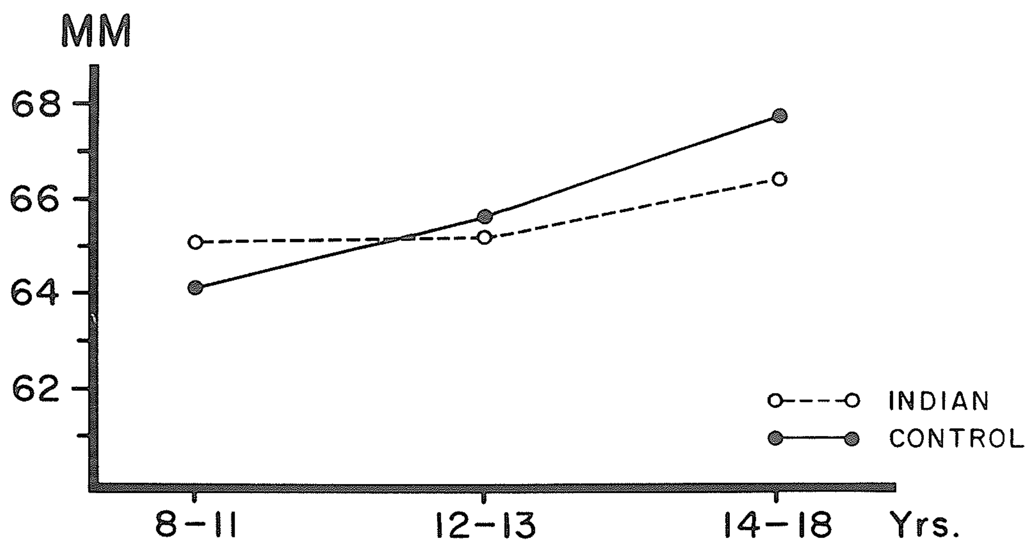
Anterior and posterior facial height measurements were made to determine differences in the spacial relationships of the bony components of the face within the two populations. These variables were the vertical distance glabella lies above SN (variable 17), total face height (variable 19), posterior upper face height (variable 22), upper face height (variable 18), lower face height (variable 20),

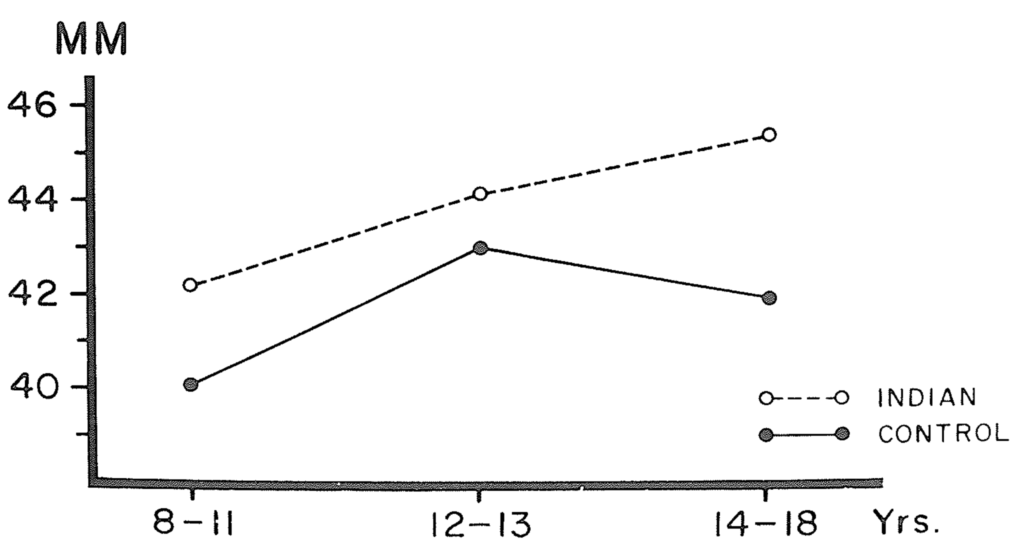
Figure 21. The effect of the group x age interaction for the linear dimension glabella to Y-plane (variable 15).

Figure 22. The effect of age on the linear dimension anterior cranial base (variable 14).

Figure 23. The effect of the group x age interaction for the linear dimension posterior cranial base (variable 4).


MM
74
72
70
68
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
68
66
64
62
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
46
44
42
40
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.

posterior lower face height (variable 23), total posterior face height (variable 21).

The distance glabella to SN plane was greater for the Indian group than the control group ($p < 0.01$). The third order interaction group x sex x age ($p < 0.01$) revealed that the difference in growth pattern between the males and females was different in the two groups as may be seen from Figure 24.

Anterior face height increased significantly with age ($p < 0.01$) as shown in Figure 25. In addition, the Indian sample exhibited greater overall anterior face height than the control sample ($p < 0.01$) and the average anterior face height for the males was greater than that for the females ($p < 0.01$).

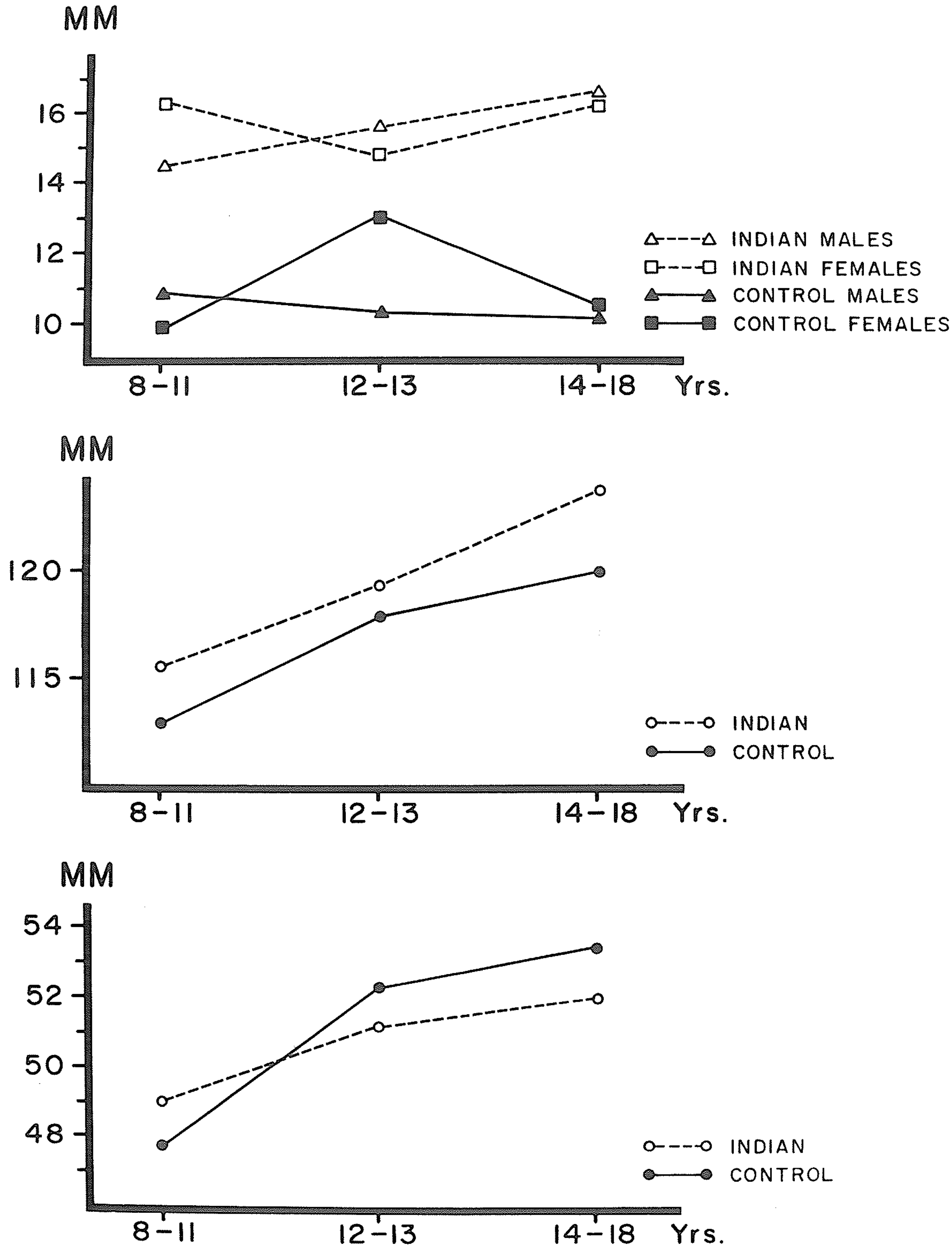
The anterior upper face height was found to be significant at the 1% level for interactions sex x age and group x age. The males had a longer anterior facial height than the females. The second order interaction indicated that the control group had a shorter upper face height at the 8-11 age group, while at the 12-13 and 14-18 age groups the control was noted to have a longer upper face height (Figure 26).

The Indian sample exhibited a greater anterior lower face height than the control sample ($p < 0.01$). In addition, the main effects of sex and age displayed significant differences at the 1% level. Generally speaking the males had a longer face height than the females and there was a linear increase in size with age. (Figure 27).

Figure 24. The effect of the group x sex x age interaction for the linear dimension glabella to anterior cranial base (variable 17).

Figure 25. The effect of age for the linear dimension total face height (variable 19).

Figure 26. The effect of the group x age interaction for the linear dimension anterior upper face height (variable 18).


MM
16
14
12
10
8-11
12-13
14-18
Yrs.
INDIAN MALES
INDIAN FEMALES
CONTROL MALES
CONTROL FEMALES
MM
120
115
8-11
12-13
14-18
Yrs.
INDIAN
CONTROL
MM
54
52
50
48
8-11
12-13
14-18
Yrs.
INDIAN
CONTROL

Differences in the posterior face height were significant ($p < 0.05$) for the main effects of group and sex while main effect of age was significant at the 1% level (Figure 28). The Indian group revealed a larger posterior face height than the control group, with the Indian males decreasing between the ages categories 8-11 years resulting in a significant sex x age interaction ($p < 0.01$).

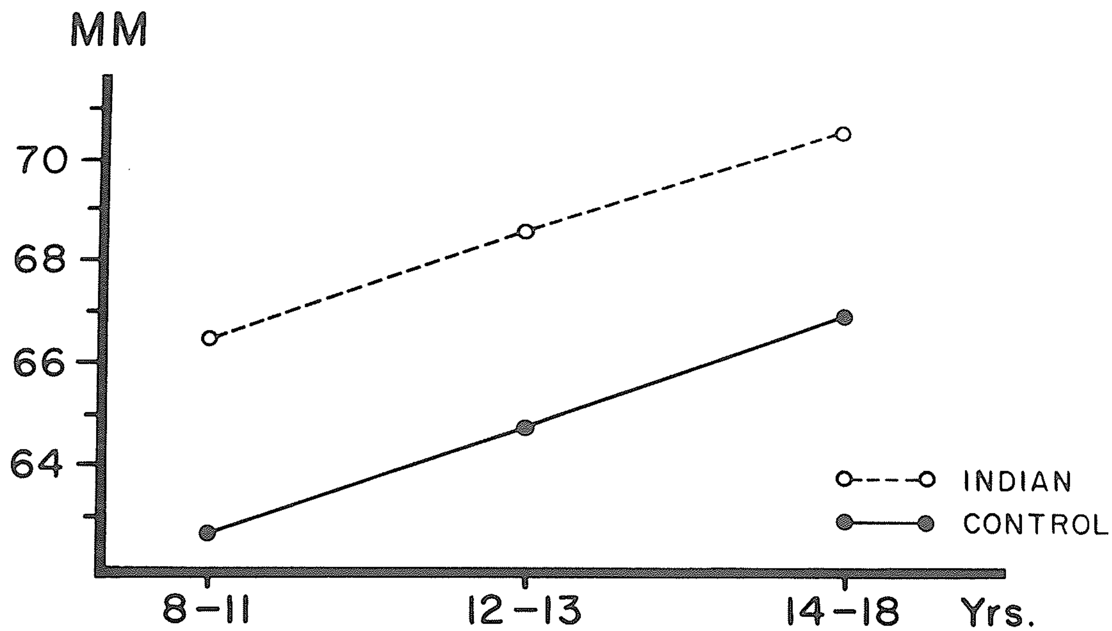
The posterior upper face height displayed significant differences for the main effects of group, sex and age ($p < 0.01$). The Indian group had a larger posterior upper face height than the control group and the males were found to be larger than the females. A significant group x age interaction ($p < 0.01$) was due to the decrease in posterior face height between the 12-13 year and 14-18 year age groups. This could be due to a sample error as cross-sectional data was utilized.

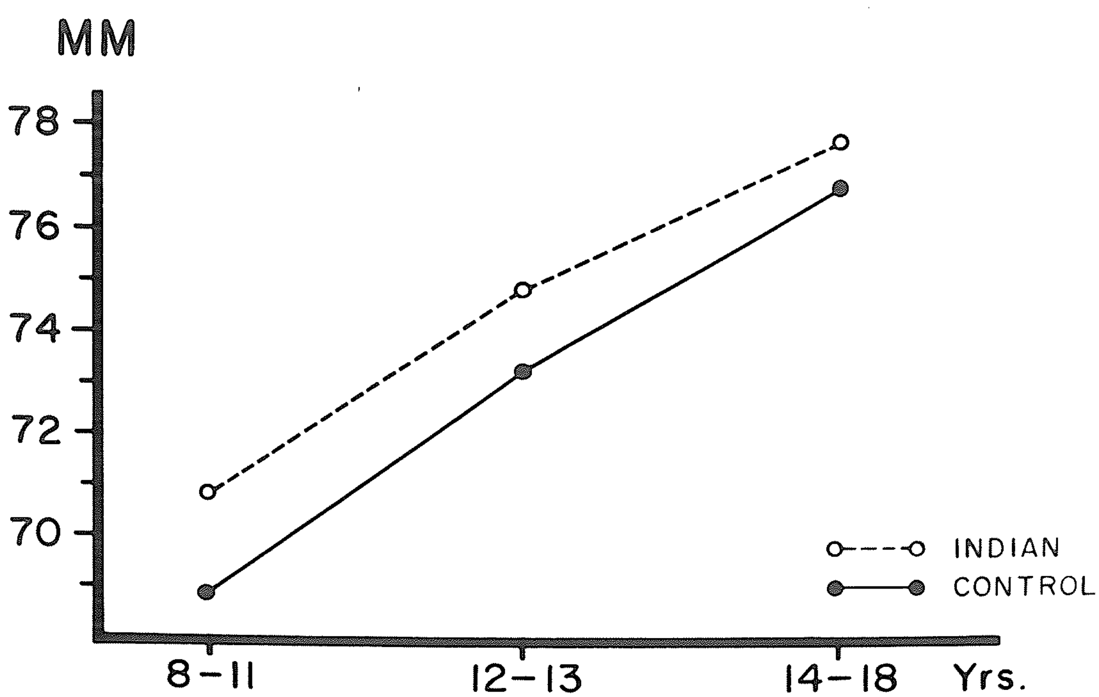
The lower posterior face height increased significantly ($p < 0.01$) with age. However the interactions of group x age and sex x age at the 5% level indicated a different development of males versus females and Indians versus controls. The lower posterior face height increased with age and the control group revealed a larger lower posterior face height possibly resulting in a flatter mandibular plane angle.

Examination of the facial height variables indicate that the Indian group displayed a greater linear dimension in all variables measured with the exception of the posterior lower face

Figure 27. The effect of age for the linear dimension anterior lower face height (variable 20).

Figure 28. The effect of age for the linear dimension posterior total face height (variable 21).


MM
70
68
66
64
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
78
76
74
72
70
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.

height and the anterior upper face height. The males were larger than the females with one exception; that being, glabella to SN, where the female was larger.

d) Development of the Bony Nose

The length of the nasal bone (variable 2) was used to study its incremental growth. The linear distance from the tip of the nasal bone to the anterior cranial base (variable 16) and the angular relationships of the nasal bone to the facial plane (variable 55) and the nasal bone to SN (variable 56) were calculated to establish the spacial orientation of the nasal complex relative to the anterior cranial base and the facial profile.

The Indian group displayed a longer nasal bone than the control group ($p < 0.01$). The nasal bone was also noted to increase in length with age ($p < 0.01$). In addition a group x age interaction was detected, however it was significant only at the 5% level. This interaction as shown in Figure 29 was due to the slight decrease in the nasal bone length between the 12-13 year and 14-18 year age groups.

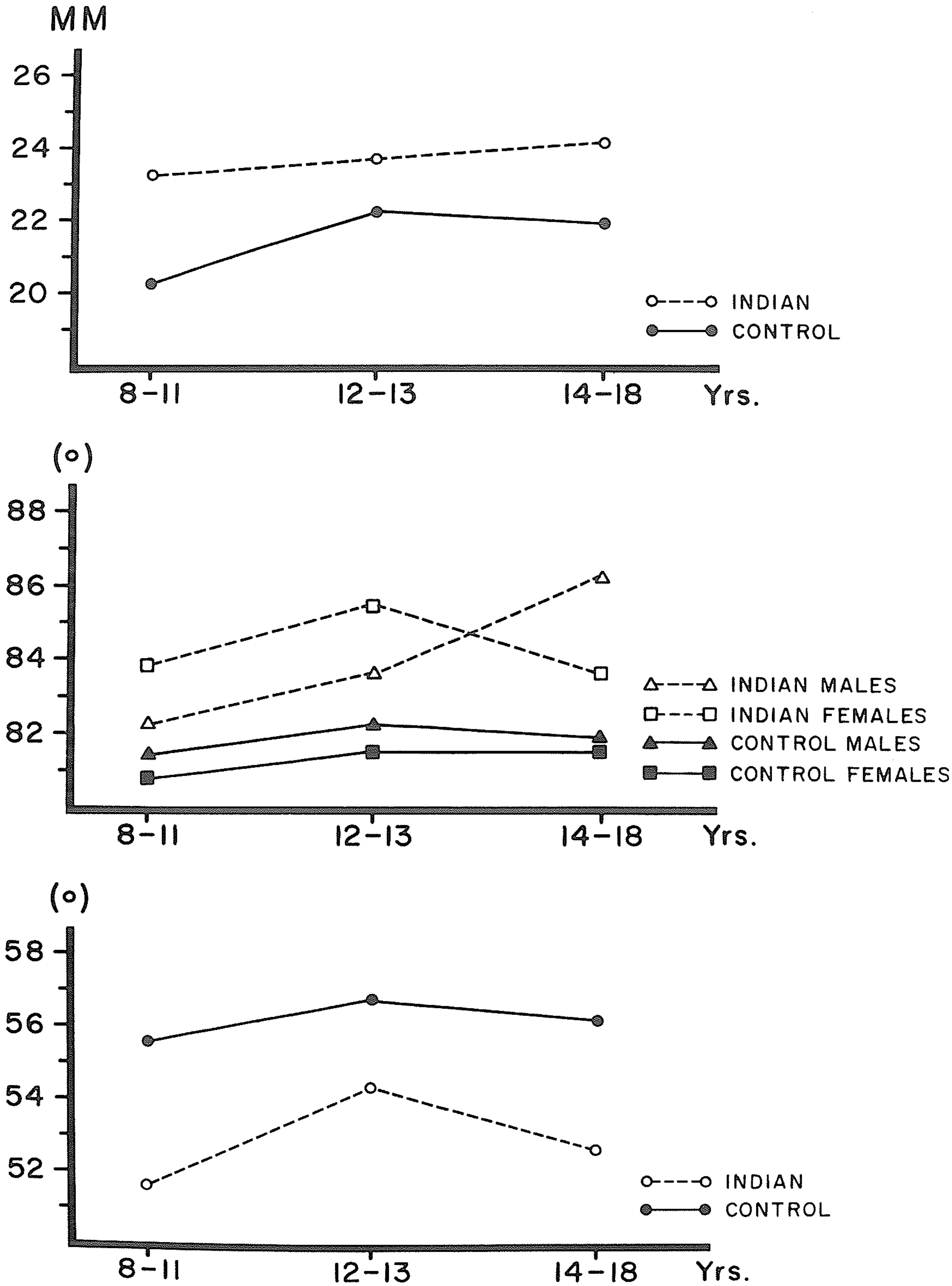
The vertical height of the nasal bone measured perpendicular to SN was longer in the Indian group than the control group ($p < 0.01$).

Significant increases ($p < 0.01$) for the main effects of age were detected for the angular relationship of the nasal bone to the anterior cranial base. The third order interaction group x sex x age ($p < 0.01$) indicated a different pattern between the males and females in the two groups. No significance was detected

Figure 29. The effect of group x age interaction for the linear dimension of the nasal bone (variable 2).

Figure 30. The effect of the third order interaction of group x sex x age for the angular measurement SNA (variable 47).

Figure 31. The effect of age for the angular measurement sella-nasion-orbitale (variable 65).


MM
26
24
22
20
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.
(o)
88
86
84
82
INDIAN MALES
INDIAN FEMALES
CONTROL MALES
CONTROL FEMALES
8-11
12-13
14-18
Yrs.
(o)
58
56
54
52
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.

between the main effects of group or sex.

Changes in the relationship of the nasal bone to the anterior facial plane was measured in order to assess the contribution of this bone to the profile. Age was found to be significant at the 1% level while the main effects of group and sex displayed no detectable significance.

Examination of the bony nose variables therefore indicate that the bony nose was longer, its tip located at a lower level and its profile slightly more prominent in the Indian group than the control group.

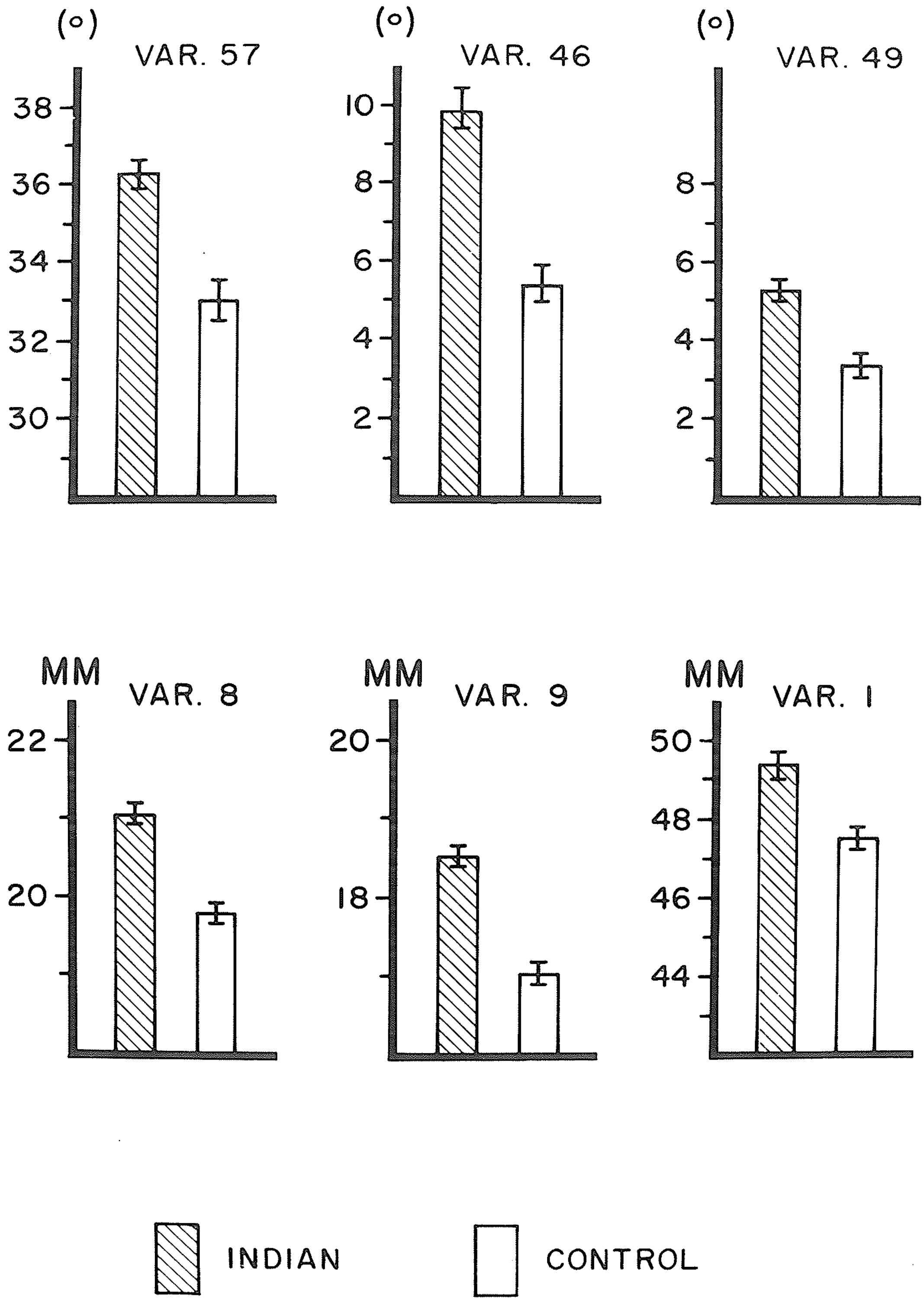
e) Maxillary Complex

Four measurements, the length of the maxillary complex (variable 1), its relationship to the anterior cranial base utilizing sella-nasion-point A angle (SNA, variable 47), palatal plane to SN (variable 58) and the retrusion of the orbit (variable 65) were used in the maxillary assessment.

Changes in the linear measurement of the anterior nasal spine to posterior nasal spine (i.e. maxillary length) were significant for all main effects. The Indian group exhibited a longer maxillary length than the control group ($p < 0.01$) (Figure 32). There were also linear increase with age ($p < 0.01$).

The variable SNA displayed significant differences between the groups ($p < 0.01$) and between ages ($p < 0.05$). The Indian group had a more prominent maxilla than the control group at all ages (Figure 30).

Figure 32. The main effect of group for the angular measurements; mandibular plane angle (variable 57), angle of convexity (variable 46), ANB angle (variable 49) and the linear measurements: upper lip to the facial plane (variable 8), lower lip to facial plane (variable 9) and the maxillary palatal length (variable 1).


(o)
VAR. 57
38
36
34
32
30
(o)
VAR. 46
10
8
6
4
2
(o)
VAR. 49
8
6
4
2
MM
VAR. 8
22
20
MM
VAR. 9
20
18
MM
VAR. 1
50
48
46
44
INDIAN
CONTROL

The angulation of the palatal plane to the anterior cranial base was greater in the control group than the Indian group ($p < 0.01$).

The relationship of orbitale to the anterior cranial base was utilized to assess midface prominence. The Indian midface was more retrusive than the control group ($p < 0.01$) and this was consistent for the three age categories ($p < 0.01$) (Figure 31).

Examination of the maxillary variables indicated that the maxilla was larger and positioned more anteriorly in the Indian group with the exception of the orbitale relationship which was more retrusive. Males were found to be larger than females in both groups.

f) Mandible

The linear and angular measurements used in this study evaluated size, form and position of the mandible.

Variable 48, the sella-nasion-point B angle (SNB) was larger in the Indian than the control ($p < 0.05$) and this variable increased with age ($p < 0.01$) for all subjects. No interaction between the main effect were observed indicating both populations had similar developmental patterns (Figure 33).

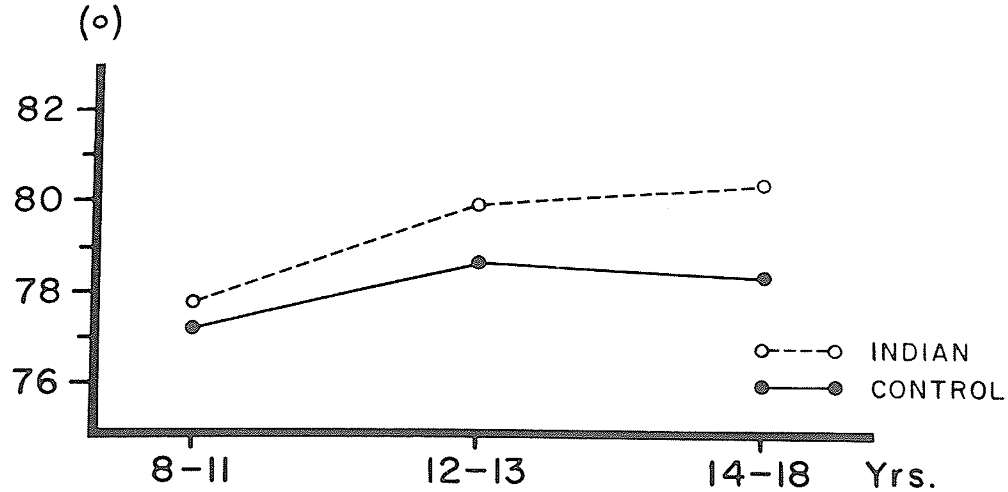
The total length of the mandible (variable 3) was larger in males than females ($p < 0.01$) and increased in size with age ($p < 0.01$) (Figure 34).

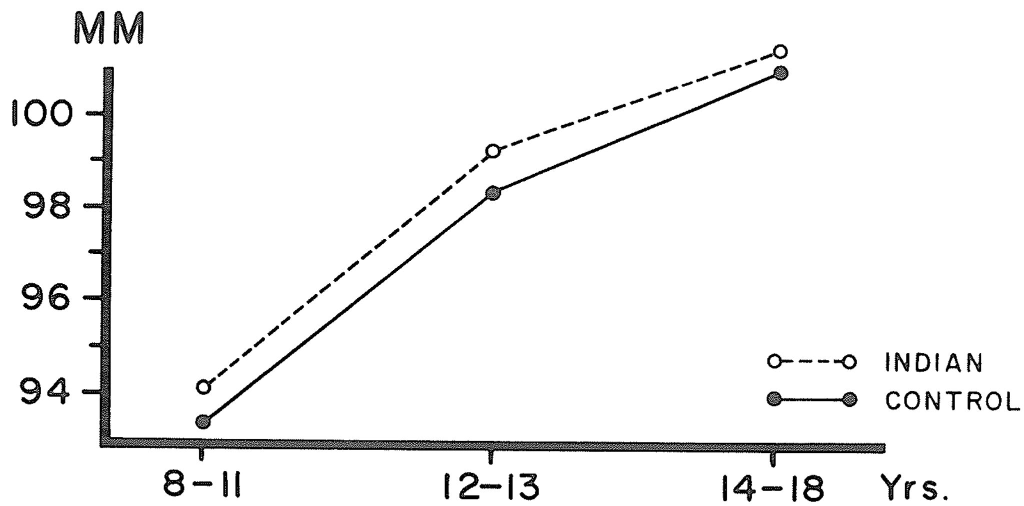
The corpus length (variable 5) revealed that the males were larger than the females ($p < 0.01$) and increased in size for all age categories ($p < 0.01$). The females appeared to terminate growth earlier than males resulting in the interaction of sex x

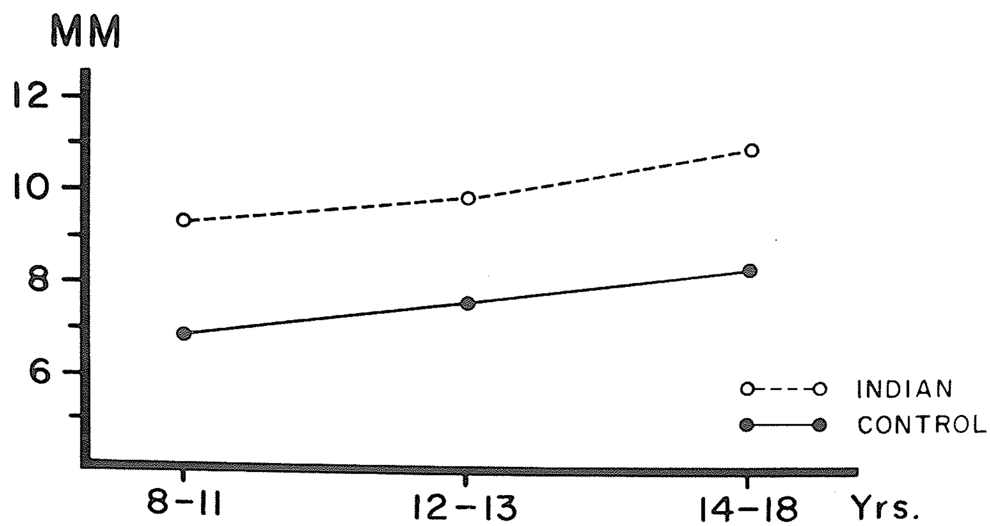
Figure 33. The effect of age for the angular measurement SNB (variable 48).

Figure 34. The effect of age for the linear dimension mandibular length (variable 3).

Figure 35. The effect of age for the linear dimension pogonion to mandibular plane (variable 11).


(o)
82
80
78
76
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
100
98
96
94
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
12
10
8
6
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.

age ($p < 0.05$).

The mandibular plane to SN (variable 57) displayed between group differences that were significant at the 1% level with the Indian group having a steeper mandibular plane than the control group (Figure 32).

The gonial angle (variable 59) revealed significant differences between age groups ($p < 0.05$). Since the male Indians and the female control has smaller gonial angles a group x sex interaction was noted ($p < 0.05$).

Measurement of the vertical height of pogonian relative to the mandibular plane (variable 11) revealed that the Indian group was larger than the control group ($p < 0.01$). As well this variable displayed a linear increase with age ($p < 0.01$) (Figure 35).

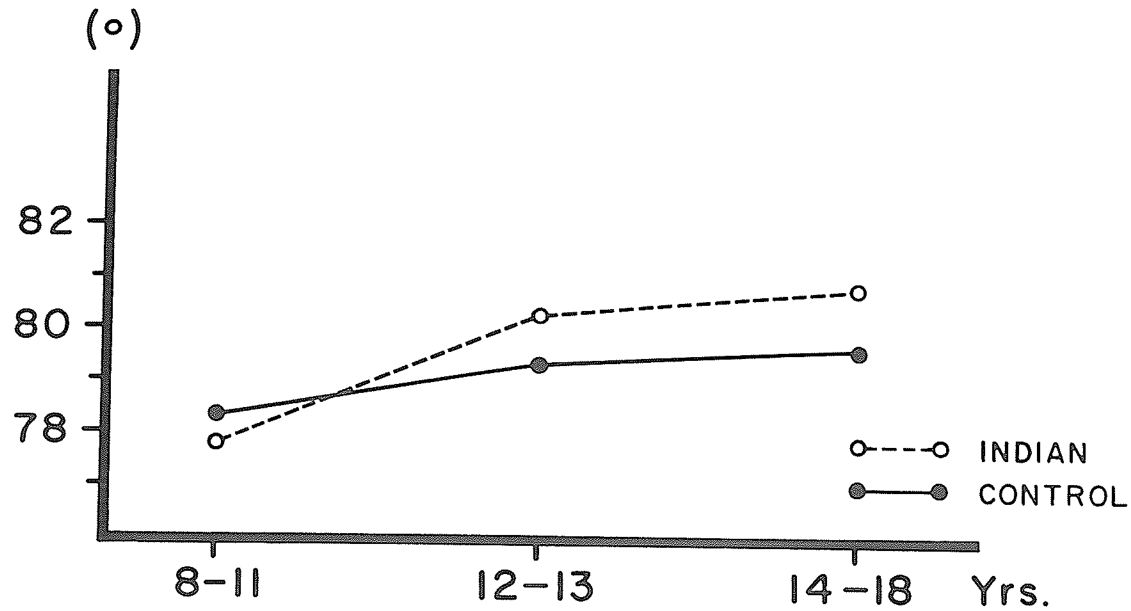
Pogonian, like A point and B point, demonstrated forward positioning with age. The angular measurement 2-4-17 (variable 60) displayed no significant differences for group or sex while a linear increase with age was noted ($p < 0.01$) (Figure 36).

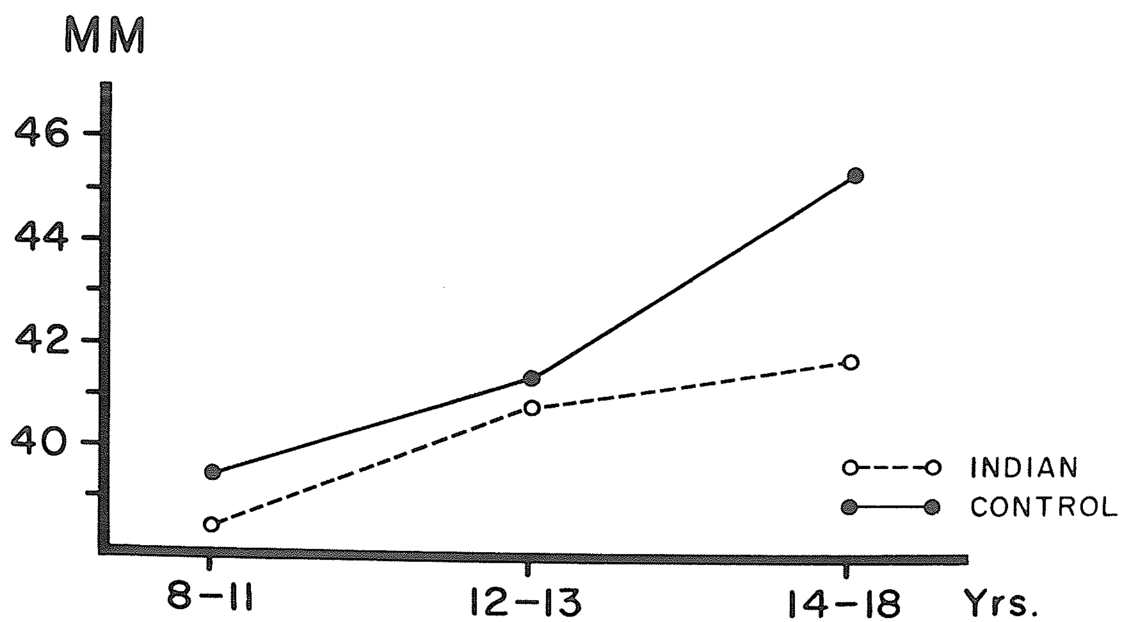
The length of the ramus (variable 26) was significant at the 1% level for the main effects of group and age. The control group exhibited a longer ramus than the Indian group and the ramus length increased with age (Figure 37).

Examination of the mandibular variables indicated that the Indian mandible was more prognathic, had a steeper mandibular plane angle and exhibited a more superiorly positioned chin point than the mandible of the control population. The mandibular length

Figure 36. The effect of age for the angular measurement sella-nasion-pogonion (variable 60).

Figure 37. The effect of age for the linear dimension ramus length (variable 26).


(o)
82
80
78
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.


MM
46
44
42
40
INDIAN
CONTROL
8-11
12-13
14-18
Yrs.

and gonial angle were noted to be very similar between groups while the ramus length was larger in the control group.

g) The Skeletal Profile

Anteroposterior linear measurements of the bony chin and the maxillary and mandibular incisors were assessed to determine their contributions to the skeletal profile. Angular measurements of facial convexity were also made to assess relative changes of the component parts of the skeletal profile.

The measurement of UI to AP (variable 27) was used to assess the position of the maxillary incisors resulting in significant differences at the 1% level between groups. Group x sex interactions ($p < 0.01$) and a third order interaction group x sex x age ($p < 0.01$) revealed that the Indian group demonstrated more maxillary incisor procumbency at all ages than did the control group (Figure 38).

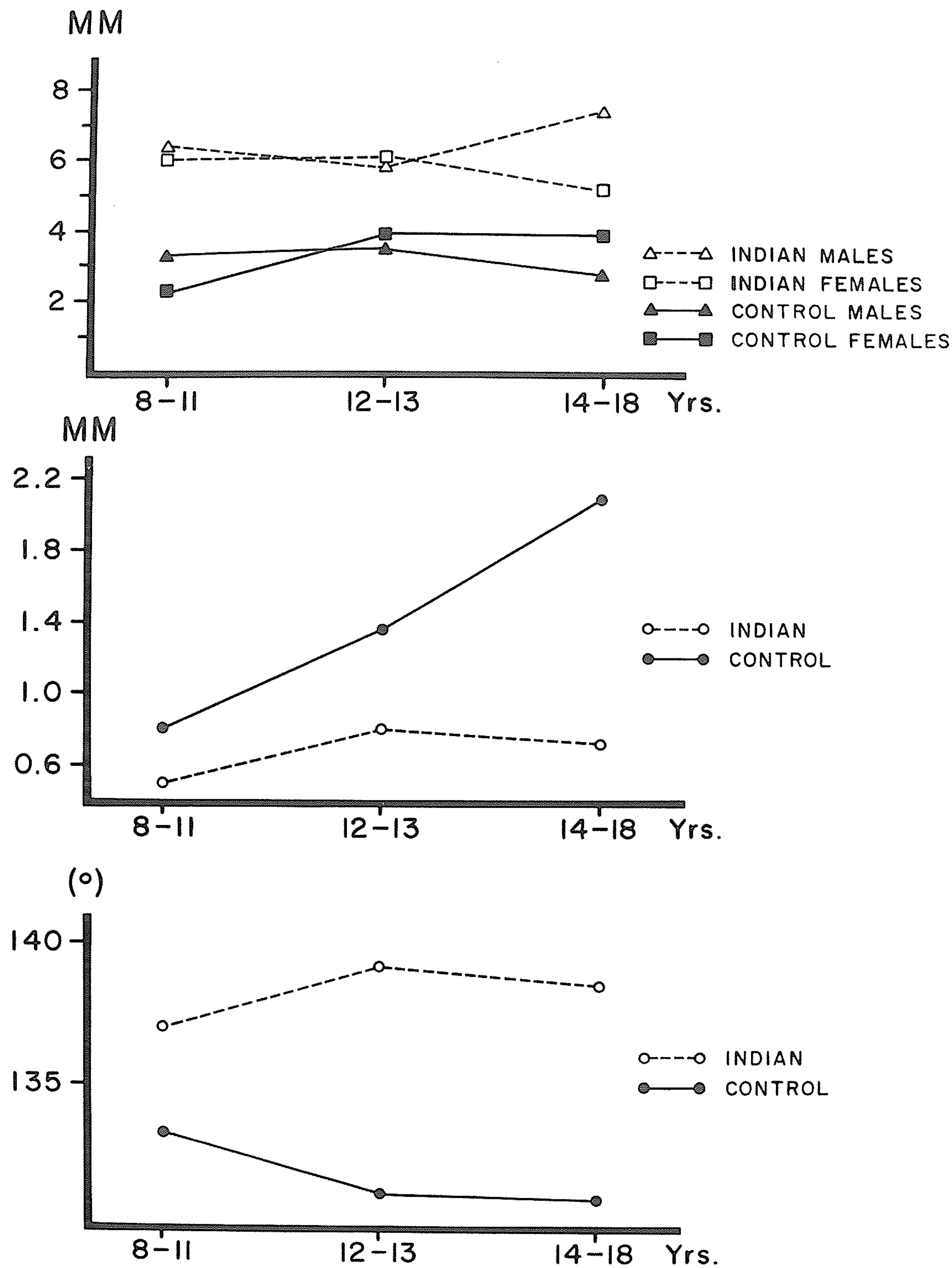
Examination of lower incisor to AP (variable 28) revealed that lower incisors were slightly more protrusive in the controls ($p < 0.05$) A group x age interaction ($p < 0.05$) was due to the decrease in the lower incisor protrusion in the control group between the 12-13 year and the 14-18 year age groups.

The bony chin point, pogonion (variable 39) displayed significant differences between the groups and between the age categories ($p < 0.01$) with the control groups exhibiting a more anteriorly positioned pogonion than the Indian group. A linear increase with age was also detected (Figure 39).

Figure 38. The effect of the third order interaction of group x sex x age for the linear measurement upper incisor to A-P (variable 27).

Figure 39. The effect of age for the linear dimension pogonion to NB (variable 39).

Figure 40. The effect of group x age interaction for the angular measurement of the overall soft tissue contour (variable 63).


MM
8
6
4
2
8-11
12-13
14-18
Yrs.
INDIAN MALES
INDIAN FEMALES
CONTROL MALES
CONTROL FEMALES
MM
2.2
1.8
1.4
1.0
0.6
8-11
12-13
14-18
Yrs.
INDIAN
CONTROL
(°)
140
135
8-11
12-13
14-18
Yrs.
INDIAN
CONTROL

The Indian group exhibited a larger angle of convexity (variable 46) than the control group ($p < 0.01$) (Figure 32).

The point A-nasion-point B angle (ANB) (variable 49) also displayed significant differences at the 1% level; the Indian group had a larger ANB angle than the control group (Figure 32).

The lower incisor to mandibular plane (variable 53) revealed that the incisors of the control group were more proclined than those of the Indian group ($p < 0.01$) while the incisors of the female group were proclined more than those of the male group ($p < 0.01$).

Examination of the skeletal facial profile variables indicated that the Indian group has a greater profile convexity and proclination of the maxillary incisors, while the mandibular incisors displayed less proclination than the control group. A smaller chin button was also evident in the Indian group.

h) Soft Tissue Profile

Measurements of the soft tissue profile were performed to determine the anteroposterior position of the nose, the lips and the chin in relation to the anterior facial plane as well as assess the overall soft tissue contour.

Pronasale to the facial plane (variable 7) displayed no significant differences for the main effect of group or sex, while the main effect of age showed significant differences ($p < 0.01$), revealing an increase in nasal prominence.

The measurement of the upper lip to facial plane (variable 8) and lower lip to facial plane (variable 9) was highly significant for the main effects of group and sex ($p < 0.01$). The Indian group revealed more anteriorly positioned lips than the control group and the male group had more lip prominance than the female group (Figure 32).

The measurement of soft tissue pogonion to the facial plane (variable 10) revealed that the Indian group was larger than the control group ($p < 0.01$). As well a linear increase with age was noted ($p < 0.01$).

The soft tissue angle of convexity (variable 64) was significantly different for the main effect of group; the Indian profile was more convex than the control profile. There was a sex x age interaction ($p < 0.01$) where females showed increases in convexity throughout the ages while the males increased between 8-11 and 12-13 years and then decreased between the ages of 12-13 years and 14-18 years.

The analysis of the overall soft tissue facial counter (variable 63) was significant for the main effect of group ($p < 0.01$) with the Indian group exhibiting a more convex profile than the control group. A group x age and sex x age interaction ($p < 0.05$) indicated that the Indian group increased in facial convexity between the ages 8-11 years and 12-13 years while the control group decreased at each age (Figure 40). The females displayed a decrease in facial convexity between the ages of 8-11 years and 12-13 years and then increased between 12-13 years and 14-18 years, while the males decreased at each age.

Examination of the soft tissue profile variables revealed that the Indians had a more convex profile and in addition displayed a thicker soft tissue thickness in relation to the facial plane than did the control group.

Discriminant Function Analysis

The variables selected for the discriminant function analysis were selected from the univariate analysis results according to the method described by Huberty (1975). This method yielded 17 linear and 11 angular measurements which are listed in Appendix VI. These variables were subjected to six discriminant function analyses with the objective of identifying variables of importance in discriminating between the Indian and control groups. The six discriminant function analyses consisted of all the Indian group versus all the control group, male Indian versus male Caucasian, female Indian versus female Caucasian, Indians between the age 8-11 years versus the control of the same age range, Indians 12-13 years old versus the same aged controls and Indians 14-18 years old versus the Caucasians of the same age bracket.

a) Indian versus Control

This discriminant analysis revealed a total of ten variables that displayed significant discriminating ability between these two groups. These variables are listed according to the order of their selection as follows:

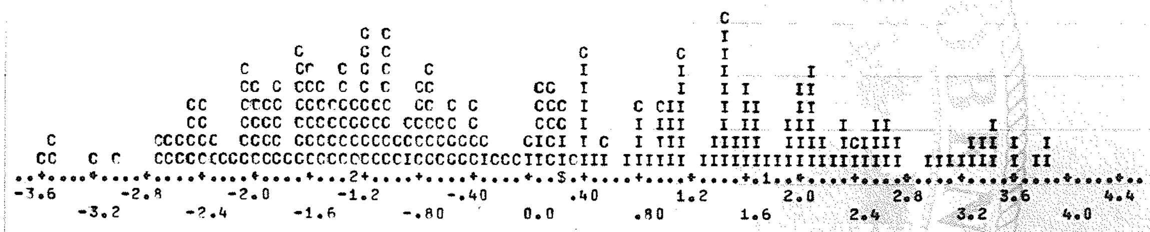
1. Vertical height of pogonion in relation to the mandibular plane (variable 11).
2. Horizontal position of the upper incisor in relation to the facial plane (variable 12).
3. Relationship of orbitale to SN (variable 65).
4. Vertical distance glabella lies above the anterior cranial base (variable 17).
5. Upper incisor to NA (variable 37).
6. SNB (variable 48).
7. Vertical distance the tip of the nasal bone lies below the anterior cranial base (variable 16).
8. Palatal plane to SN (variable 58).
9. Lower incisor to NB (variable 68).
10. Total face height (variable 19).

This discriminant analysis correctly classified 93.6% of the total sample. This was displayed by the fact that 97 out of 104 Indians and 138 out of 145 controls were properly categorized (Figure 41).

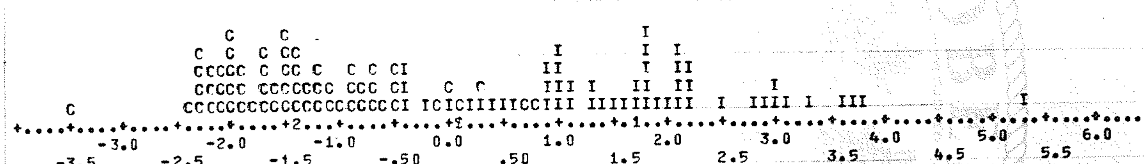
The standardized canonical coefficients which indicate the direction and power of each variable are listed in column I of Table V. The mean canonical score for the Indians was 1.75 and that for the control was -1.24, where the positive canonical coefficients indicate a variable positively related to Indian tendencies. These included variables 48, 11, 12, 16, 37, 19 and 17, as well, smaller

Figure 41. Positions of all the subjects on the discriminant function.

Figure 42. Positions of the male subjects on the discriminant function.



ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS



ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS measurements for variables 58, 65 and 68, also indicated Indian tendencies.

b) Male Indian Versus Male Caucasian

This investigation revealed that a total of seven variables contributed significantly to the discriminating ability between the Indian and control groups which resulted in 92.9% of the males being correctly classified. These variables are listed according to the order of their selection:

1. Vertical height of pogonion in relation to the mandibular plane (variable 11).
2. Vertical distance glabella lies above the anterior cranial base (variable 17).
3. Vertical distance the tip of the nasal bone lies below the anterior cranial base (variable 16).
4. Relationship of orbitale to SN (variable 65).
5. Lower incisor to mandibular plane (variable 53).
6. Angle of convexity (variable 46).
7. Palatal plane to SN (variable 58).

There were 46 out of 51 male Indians and 59 out of 62 males control grouped correctly (Figure 42). The standardized canonical coefficients are listed in Column II of Table V, with the mean canonical score for the Indians was 1.66 and that for the control -1.36. The variables positively related to male Indian tendencies were variables 46, 11, 16 and 17 while smaller measurements of variables 53, 58 and 65 indicated male Indian tendencies.

c) Female Indian Versus Female Caucasian

The seven variables that contributed significantly to this discrimination are listed as follows according to the order to their selection:

1. Vertical height of pogonion in relation to the mandibular plane (variable 11).
2. Angle of convexity (variable 46).
3. Relationship of orbitale to SN (variable 65).
4. SNA (variable 47).
5. Vertical distance the tip of the nasal bone lies below the anterior cranial base (variable 16).
6. Lower incisor to NB (variable 68).
7. Lower incisor to AP (variable 28).

This discriminant analysis correctly classified 92% of the females, with 50 out of 53 Indians and 77 out of 85 controls properly categorized (Figure 43). The standardized canonical coefficients are listed in Column III of Table V, with the mean canonical score for the Indian 1.81 and that for the control -1.13. The variables positively related to female Indian tendencies are 46, 47, 11 and 16. Female Indian tendencies can also be characterized by smaller measurements of variables 28, 65 and 68.

d) Indian Versus Caucasian (8-11 years)

The following variables contributed significantly to this discrimination and are listed according to the order of their selection:

1. Vertical height of pogonion in relation to the mandibular

Figure 43. Positions of the female subjects on the discriminant function.

Figure 44. Positions of the 8-11 year old subjects on the discriminant function.

```
                                         C                           I   I
                                CC   CC  C                       1   I   I
                   C  CCCCCC    CCC  CC  CC                      I   I   I I  I
          C C      C  CCCCCC   CCCCC CC  CCC    CC   CCC   CII CIIII II  II I  I
  CC  C  CCCC   CCCCCCCCCCCCC CCCCCCCCCCCCCCI C CICICIIIC IIII IIIIICIIIIIIIII  II  I I     III  I
.+....+....+....+....+....+....+2...+....+....+....$+....+....+....+..1.+....+....+....+....+....+....+...
          -2.8      -2.0      -1.2      -.40       .40       1.2       2.0       2.8       3.6       4.4
     -3.2      -2.4      -1.6      -.80       0.0       .80       1.6       2.4       3.2       4.0

  ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS
```

```
                 C                    C          C           I
                 C CC C               C          I           I  I  I
         CC C CC C CC C     C  C      C    C C   I       I   II I II     I    I
   C C C CCC C CCCCCCCCCCC CCC C CC C IC   IIC  IIICC I  I III IIIIIIIIIII III     I I  I     I I
...+....+....+....+....+2...+....+....+....+$...+....+....+....+.1..+....+....+....+....+....+....+....+.
-3.2     -2.4       -1.6      -.80      0.0       .80       1.6       2.4       3.2       4.0       4.8
      -2.8      -2.0      -1.2      -.40       .40       1.2       2.0       2.8       3.6       4.4

  ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS
```

plane (variable II).

2. Horizontal position of the upper incisor in relation to the facial plane (variable 12).
3. Relationship of orbitale to SN (variable 65).
4. Vertical distance the tip of the nasal bone lies below the anterior cranial base (variable 16).
5. SNA (variable 47).
6. Lower incisor to NB (variable 68).
7. Vertical distance glabella lies above the anterior cranial base (variable 17).

This discriminant analysis correctly classified 41 out of 44 Indians and 46 out of 51 controls 91.6% (Figure 44). The standardized coefficients are listed in column IV of Table V. The mean canonical score for the Indian group was 1.73 and that for the control group was -1.49. The variables positively related to an 8-11 year old Indian are 47, 16, 11, 12 and 17 while smaller measurements for variables 65 and 68 also indicated 8-11 year old Indian tendencies.

e) <u>Indian Versus Caucasian (12-13 years)</u>

The following variables contributed significantly to the discrimination resulting in 36 out of 38 Indians and 44 out of 49 controls (92%) correctly classified (Figure 45). These variables are listed according to the order to their selection as follows:

1. Vertical height of pogonion in relation to the mandibular plane (variable 11).
2. Angle of convexity (variable 46).

Figure 45. Positions of the 12-13 year old subjects on the discriminant function.

Figure 46. Positions of the 14-18 year old subjects on the discriminant function.

```
                             C                   I
                             CC                  I        C   I
                C  C CC C CCCCC  C   C     CC    IC   I   I   I II  I I   I                 I
    C      C   CCCC CCCC  CCCCC CCCCCCCCC  ICCC IICIICI   I  CIIIIIIIIIII  II I I   I II     I
..+....+....+....+....+....+....2....+....+....+.$..+....+....+...1+....+....+....+....+....+....+....+..
-3.6      -2.8      -2.0      -1.2      -.40       .40       1.2       2.0       2.8       3.6       4.4
     -3.2      -2.4      -1.6      -.80       0.0       .80       1.6       2.4       3.2       4.0

  ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS
```

```
               C C  CC                                          I                I
    C          C CCCCC CC   CC  CC    C                         II       I       I
   CC C CCCC CCCCCCCCCCCCCCCCCCCCCC   C       II      I      I II   I   IIIII   I I   I      I
..+....+....+....+...2+....+....+....+....+...$+....+....+....+....+...1+....+....+....+....+....+....+..
-3.5      -2.5      -1.5      -.50       .50       1.5       2.5       3.5       4.5       5.5       6.5
     -3.0      -2.0      -1.0       0.0       1.0       2.0       3.0       4.0       5.0       6.0

  ON THE AXIS $ INDICATES DIVIDING POINT AND NUMBERS THE GROUP MEANS
```

3. Lower incisor to mandibular plane (variable 53).
4. Maxillary arch length (variable 29).
5. Relationship of orbitale to SN (variable 65).
6. Mandibular plane to SN (variable 57).

The standardized canonical coefficients are listed in Column V of Table V. The mean canonical score for the Indian group was noted to be 1.55 while that for the control group was -1.2. The variables positively related to a 12-13 year old Indian are 46, 29 and 11, also smaller measurements for variable 53, 65 and 57 displayed Indian tendencies.

f) Indian Versus Caucasian (14-18 years)

The following variables that contributed significantly to the discrimination are listed according to the order of their selection:

1. Vertical distance glabella lies above the anterior cranial base (variable 17).
2. Vertical height of pogonion in relation to the mandibular plane (variable 11).
3. Angle of convexity (variable 46).
4. Relationship of orbitale to SN (variable 65).
5. Posterior upper face height (variable 22).
6. Maxillary palatal plane length (variable 1).

This discriminant analysis correctly classified 98.6% of the Indian and control groups, with 21 out of 22 Indians and 47 out of 47 controls categorized correctly (Figure 46). The standardized canonical coefficients are listed in column VI of Table VI. The mean canonical score for the Indian group was 3.36 and that for the control group was -1.57. The variables positively related to a 14-18 year old Indian are 1, 46, 11, 17 and 22 while a smaller measurement for variable 65 indicated an Indian tendency.

TABLE V

Standardized Canonical Coefficients for the Six Discriminant Analyses

Variable	I Group	II Male	III Female	IV Age Group I	V Age Group II	VI Age Group III
LI NB (68)	-1.3000021	-	-1.25806	-.34306	-	-
UI FP (12)	1.21333	-	-	.51046	-	-
6 to SN (65)	- .5385	- .51309	- .67086	-.59179	- .47190	- .77424
Pog. to M.P. (11)	.51012	.34777	.44119	.33807	.50597	.66409
Nasal bone to SN (16)	.48959	.52142	.38684	-	-	-
SNB (48)	.48858	-	-	-	-	-
UI NA (37)	- .37063	-	-	-	-	-
Pal. Plane to SN (58)	- .27909	- .42252	-	-	-	-
TFH (19)	- .26399	-	-	-	-	-
Glab. to SN (17)	.26259	- .47567	-	.28005	-	.72343
Angle of Convexity (46)	-	.54844	.67775	-	.62823	1.93566
LI MP (53)	-	.37414	-	-	-1.21815	-
LI AP (28)	-	-	1.15865	-	-	-
SNA (47)	-	-	.85844	.39767	-	-
Length of Nasal Bone (2)	-	-	-	.47443	-	-
Max. Arch (29)	-	-	-	-	.80388	-
MP SN (57)	-	-	-	-	-.38419	-
Post. UFH (22)	-	-	-	-	-	.51533
Max Pal. Plane (1)	-	-	-	-	-	.44687

Cephalometric Assessment of the Acceptable Occlusion Group

The means and standard deviations from the Indian acceptable occlusion group for the various analyses (Downs, Holdaway, Riedel, Tweed, Manitoba and Wylie), together with the appropriate Caucasian values determined by the above authors are presented in Tables VI-X respectively.

In general, the mean values for the Indian acceptable occlusion group were noted to be similar to the control values with the exception of the Downs analysis. The values of the Indian group displayed a more convex profile and proclined maxillary and mandibular incisors in comparison to a very straight profile and upright incisors of the Downs sample.

The Manitoba analysis (Table IX) is discussed separately as the control group was selected from the Winnipeg area. Therefore a comparison of the craniofacial aspects of the Indian with acceptable occlusion living on the Peguis Indian reserve and the Caucasian with an acceptable occlusion living in the Winnipeg area may be performed. Examination of the Manitoba analysis reveals that only two measurements in the Indian sample were as great or greater that 1 standard deviation from the mean value of the control group. These variables were the angle of convexity and the angular relationship of the mandibular plane to the Frankfort Horizontal. According to this analysis, skeletal and dental pattern of the Indian acceptable occlusion group living on the Peguis Indian reserve was very similar to that of the Caucasian acceptable occlusion group selected from the Winnipeg area.

TABLE VI

Downs Analysis for the Acceptable Occlusion Group.

Variable	Control*			Indian		
Skeletal Pattern	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.
Facial Angle (o)	82.0	87.8	95.0	80.5	84.9	91.5
Convexity (o)	-8.5	0.0	10.0	-2.1	9.5	12.1
A-B Plane (o)	-9.0	-4.8	0.0	-11.0	-7.0	-1.0
Mandibular Plane (o)	17.0	21.9	28.0	22.0	31.5	35.0
Y-Axis Angle (o)	53.0	59.4	66.0	54.0	62.7	67.8
Dentition to Skeletal Pattern						
Occlusal Plane (o)	1.5	9.5	14.0	2.9	11.6	15.0
Interincisal (o)	130.0	135.4	150.0	113.0	126.8	138.7
$\overline{\text{I}}$ to Occlusal Plane (o)	3.5	14.5	20.0	4.6	13.0	20.3
$\overline{\text{I}}$ to Mandibular Plane (o)	-8.5	1.4	7.0	-5.8	4.6	10.1
$\underline{\text{I}}$ to A-P Plane (mm)	-1.0	2.7	5.0	2.0	5.5	8.4

* Downs, 1952.

TABLE VII

Holdaway - Riedel Analysis for the Acceptable Occlusion Group.

Variable	Control MEAN	Indian MEAN
SNA $^{(o)}$	80.8	83.9
SNB $^{(o)}$	78.0	80.2
ANB $^{(o)}$	+2.8	+3.7
$\overline{\text{I}}$ to NB (mm)	-	+6.6
P to NB (mm)	-	+ .3

* Holdaway, 1956.

TABLE VIII

Tweed Analysis for the Acceptable Occlusion Group.

	Control + MEAN	Indian MEAN
$\overline{\text{I}}$ to Mandibular Plane $^{(o)}$	90.0	94.6
$\overline{\text{I}}$ to Frankfort Horizontal $^{(o)}$	65.0	53.9
Mandibular Plane Angle $^{(o)}$	25.0	31.5

+ Tweed, 1954.

TABLE IX

Manitoba Analysis for the Acceptable Occlusion Group.

Variable	Control*		Indian	
	Mean	S.D.	Mean	S.D.
Facial Angle (o)	85.9	3.5	84.9	3.4
Angle of Convexity (o)	5.1	4.5	9.5	4.0
SNA (o)	82.0	3.3	83.0	3.1
SNB (o)	79.0	3.4	80.2	2.5
ANB (o)	2.9	1.6	3.7	1.9
Mandibular Plane (o) (F.H.)	25.3	4.7	31.5	3.8
U1 to L1 (o)	126.7	9.0	126.8	7.1
U1 to SN (o)	103.8	5.6	102.6	5.4
U1 to AP (mm)	5.9	1.7	5.5	1.8
L1 to MP (o)	7.6	7.2	4.6	4.6
L1 to AP (mm)	2.6	1.6	3.6	1.7
L1 to NB (mm)	4.8	2.0	6.6	1.7
P to NB (mm)	1.0	1.3	0.3	1.2

* Beaton, 1973.

TABLE X

Wylie Analysis for the Acceptable Occlusion Group.

Assessment of Anteroposterior Dysplasia

Variable	Control*		Indian	
	Male	Female	Male	Female
Glenoid Fossa to Sella (mm)	18.0	17.0	18.0	17.0
Sella to PTM (mm)	18.0	17.0	19.0	19.0
Maxillary Length (mm)	52.0	52.0	53.0	54.0
PTM to 6 (mm)	15.0	16.0	14.0	14.0
Mandibular Length (mm)	103.0	101.0	110.0	108.0

Assessment of Vertical Dysplasia

Total Face Height (mm)	114.92	112.93	120.0	118.0
Upper Face Height (mm)	50.08	48.80	51.9	51.3
Lower Face Height (mm)				
$\frac{U.F.H.}{T.F.H.} \times 100$ (%)	43.62	43.24	43.25	43.47

* Wylie, 1947.

Maturity Assessment of the Indian Population

The 94 hand-wrist films of the Indian group were used to estimate the skeletal age using the TW2 method (Tanner-Whitehouse, 1975). The maturity score and the chronologic age for the females and for the males are shown in Figure 47 and 48 respectively. The plotted position of each Indian child is shown on the percentile distribution of the TW2 maturity score sheets. These plots reveal that the skeletal age closely approximated the chronologic age for both male and female samples, although the chronologic age was generally noted to be advanced in comparison to the skeletal age.

The chronologic age was also plotted against the skeletal age as shown in Figure 49. This plot revealed that the skeletal age for the Indian sample was slightly retarded. This was determined by comparing the number of subjects above the 45° oblique line (Chebib, 1977).

Therefore, using these two methods, the TW2 and 45° oblique line, the interpretation that the skeletal age in relation to the chronologic age is slightly retarded for this particular Indian group is warranted.

Figure 47. Skeletal scores for the female Indians (after Tanner, Whitehouse, 1975).

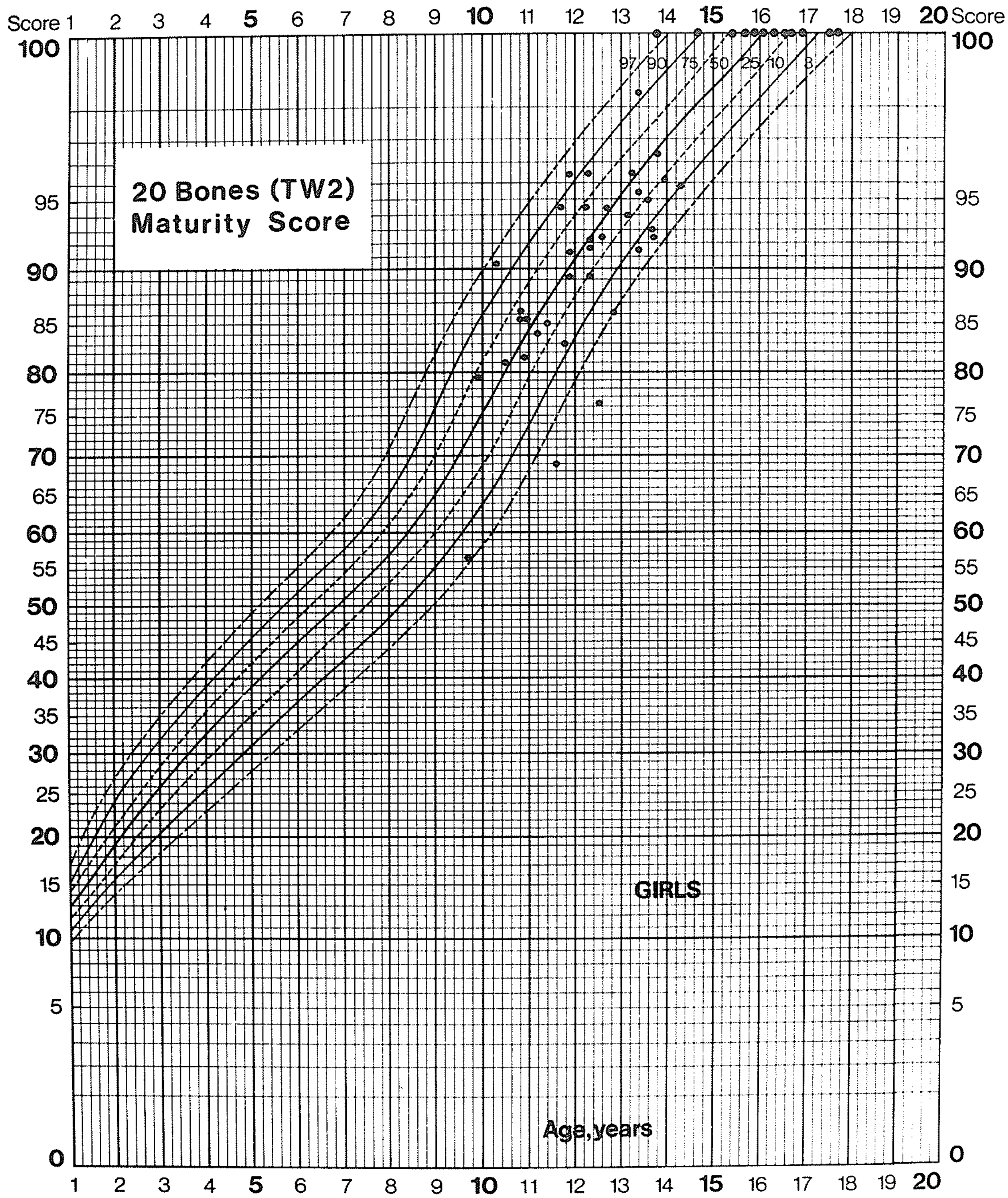

20 Bones (TW2)
Maturity Score
GIRLS
Age, years
Score
97
90
75
50
25
10
3

Figure 48. Skeletal scores for the male Indians (after Tanner, Whitehouse, 1975).

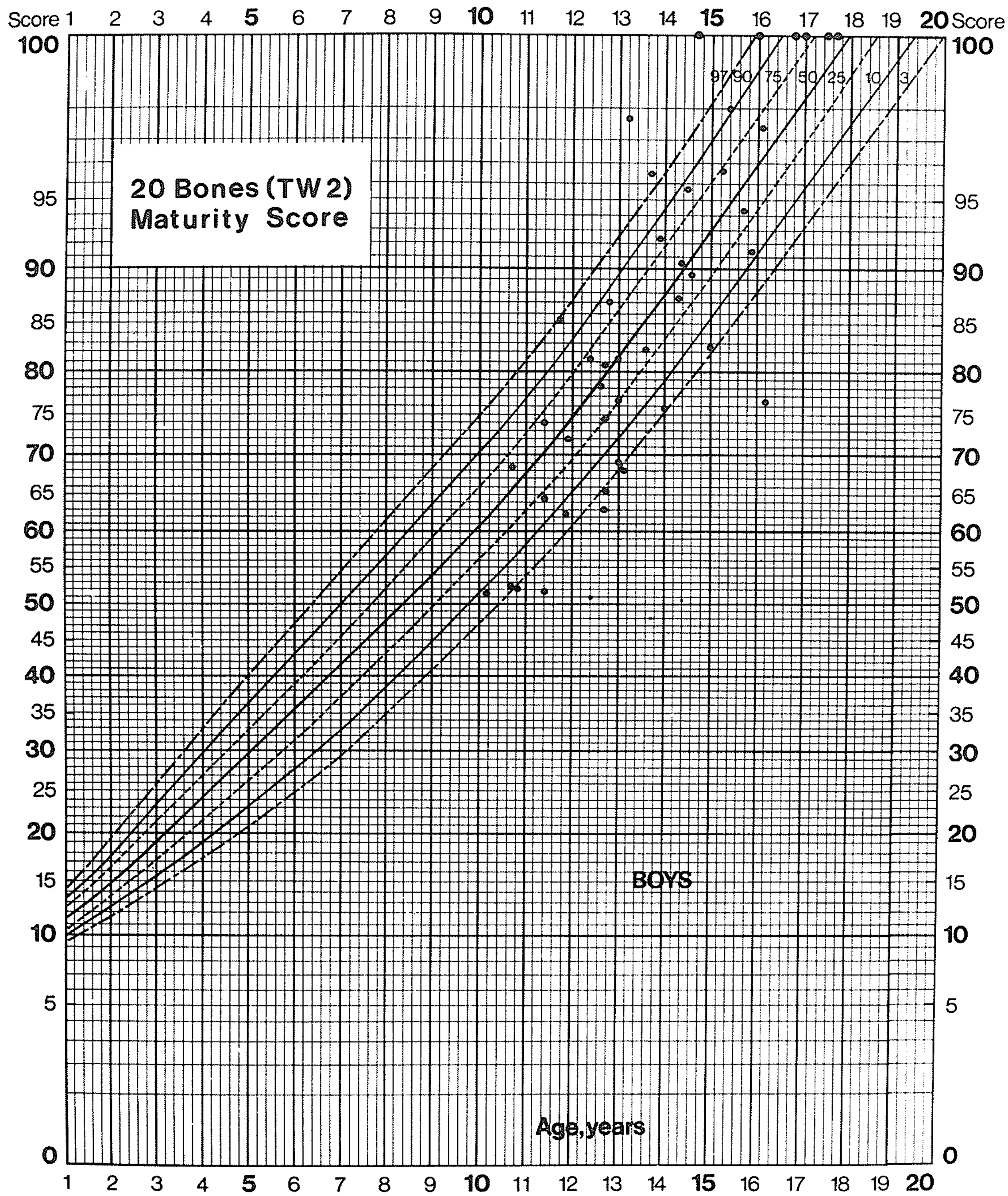
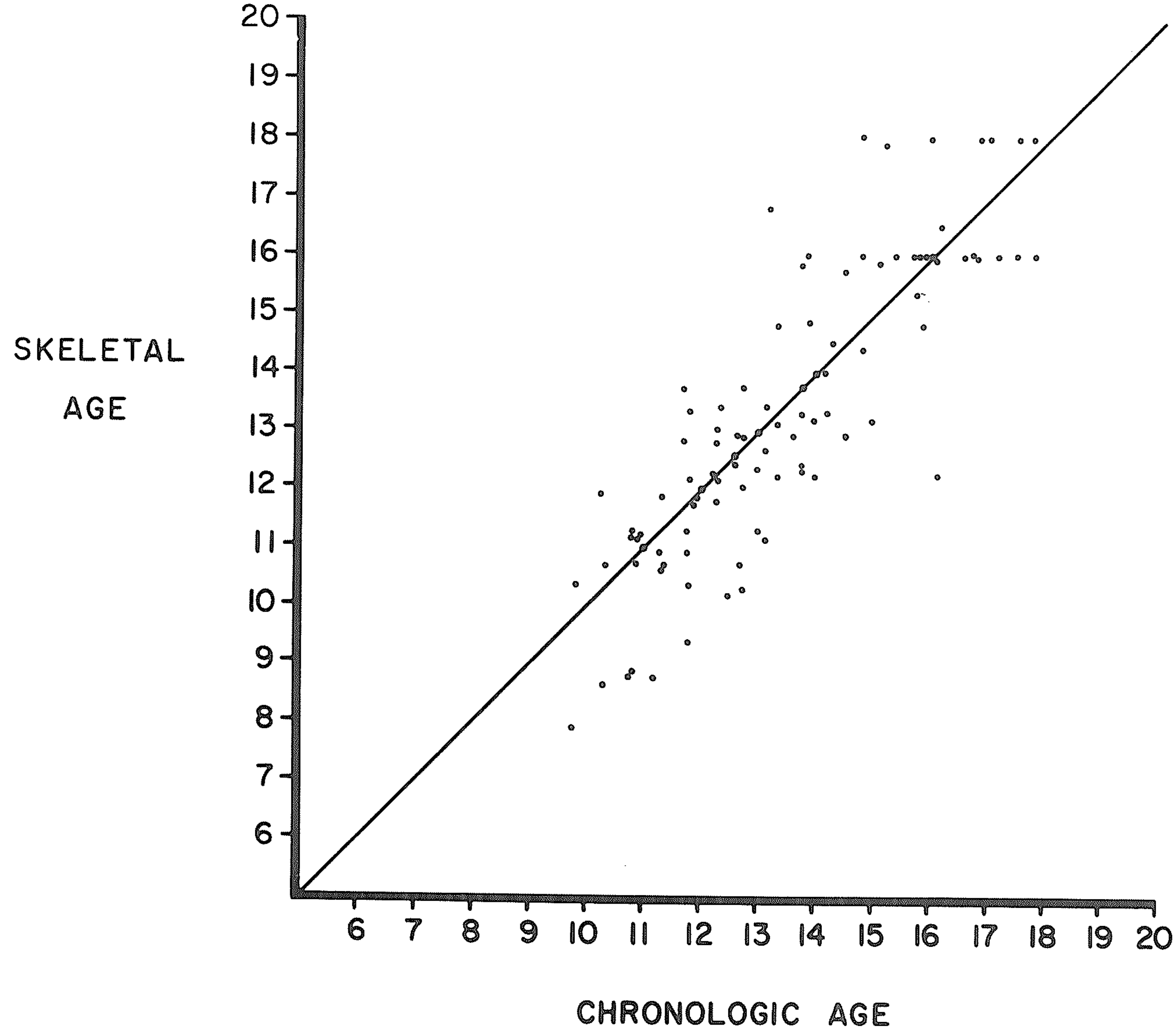

20 Bones (TW2)
Maturity Score
Score
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
97 90 75 50 25 10 3
BOYS
Age, years

Figure 49. Chronologic age versus skeletal age of all the Indian Children (r = 0.855).


SKELETAL
AGE
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19
18
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CHRONOLOGIC AGE

DISCUSSION

CHAPTER V

DISCUSSION

The present cephalometric investigation was undertaken to determine the normal range and variation that constitutes the profile of the North American Indian child living on the Peguis Indian Reserve in Manitoba and to determine if in fact, these measurements are statistically different from those of Winnipeg Caucasian children. Univariate and multivariate analyses, as well as an assessment of an acceptable occlusion group were utilized to examine these contrasts.

Overall Development of the Craniofacial Complex

The craniofacial complex of the Indian children residing on the Peguis Indian Reserve was larger than that of the Caucasian control sample in the three age categories included in this investigation. These findings are comparable to those of Hrdlicka (1940) who noted the Indian skull to be larger than that of the Caucasian. Figure 50 compares the facial polygons of the Indian and control populations in the three age ranges studied. The polygons were superimposed on the sella-nasion line at sella. There was a trend towards sexual dimorphism with the males being generally larger than the females in most dimensions of the craniofacial complex (Table XIII).

Figure 50. Comparison of the developmental trends of the Indian group versus the control group.

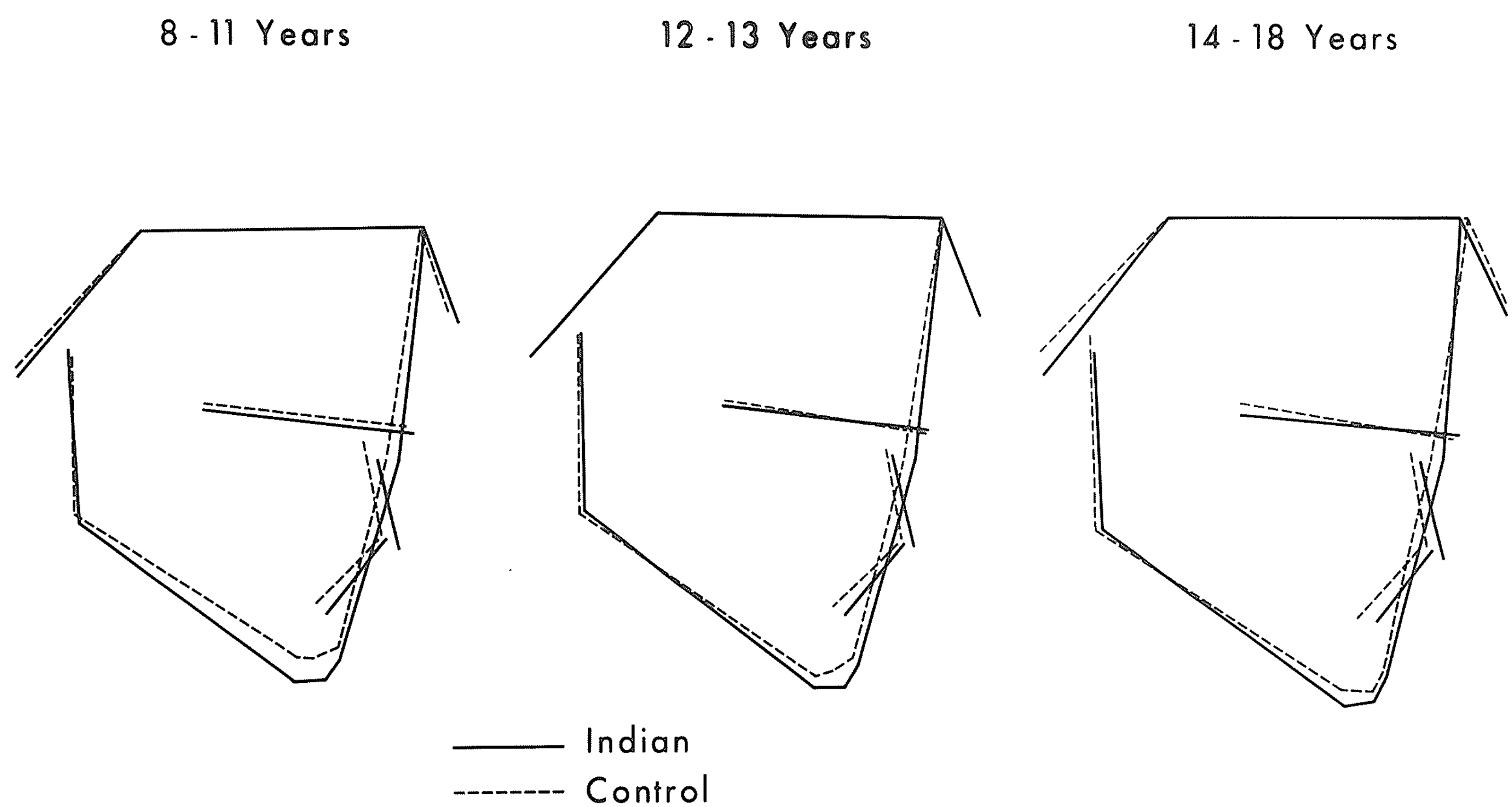
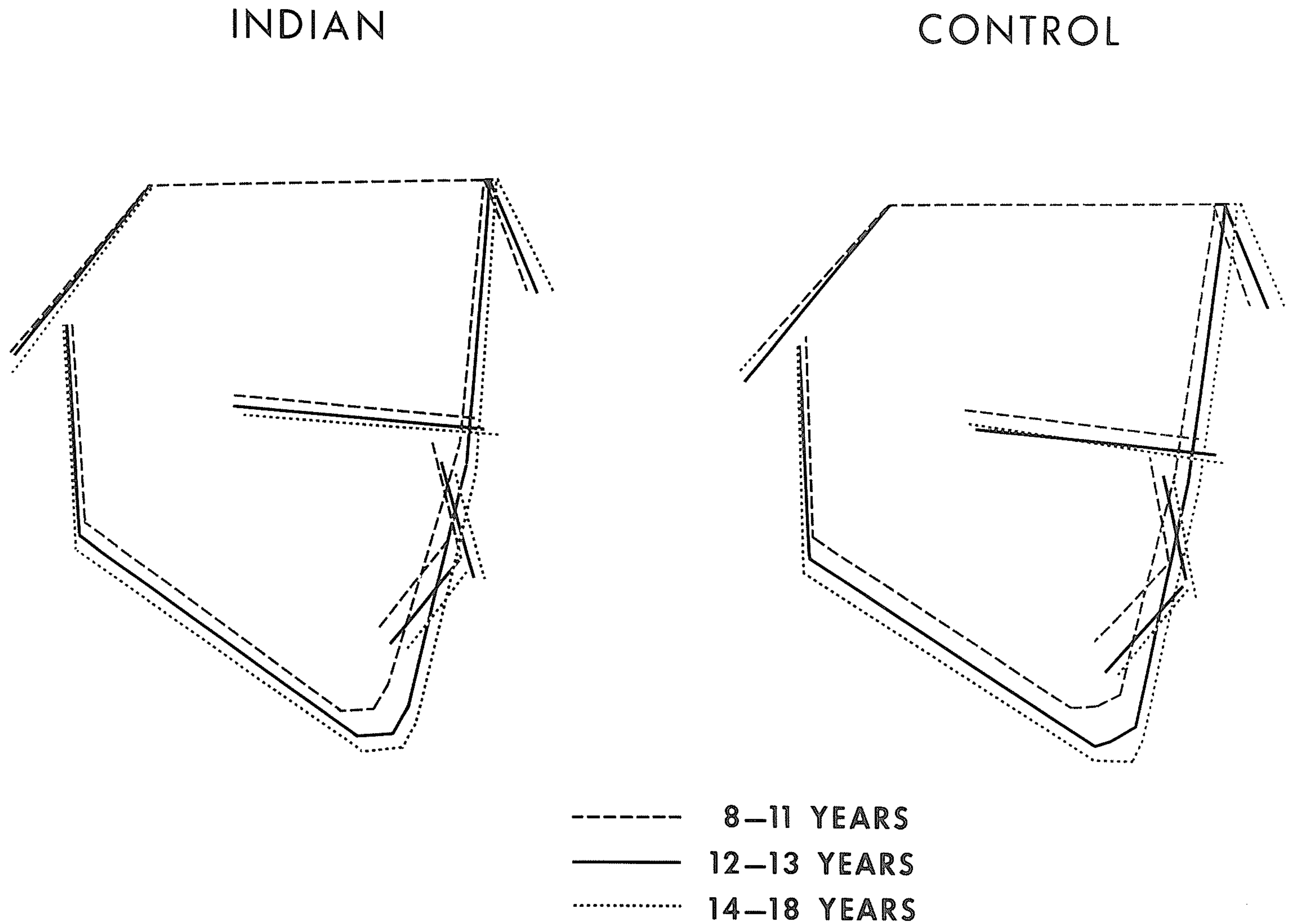

8 - 11 Years
12 - 13 Years
14 - 18 Years
Indian
Control

Figure 51. Development of the craniofacial complex in the Indian and control group based on the means of the cephalometric measurements for the three age categories.


INDIAN
CONTROL
8–11 YEARS
12–13 YEARS
14–18 YEARS

Aside from the relative overall size differential between the Indian and the Caucasian craniofacial complex, other significant differences were noted. For example, the Indians displayed a more anteriorly positioned maxilla, steeper mandibular plane to sella-nasion or Frankfort Horizontal and more protrusive maxillary incisors. This Indian group may further be described as having a convex mesognathic profile with the skeletal chin point in "harmony" with the face: the facial convexity is due to a prominent maxilla.

Development of the craniofacial complex of both the Indian and control population is shown in Figure 51 for the three age categories. The pattern of development of the craniofacial region was generally similar to the cross-sectional study described for Caucasians by Broadbent (1937) and the serial study of Caucasians by Barnes (1954).

Mean values were used in the analysis of this cross-sectional data and construction of the polygons, hence the individual variations in rate and direction of development could not be determined, although the existence of such variation within the individuals of each population is recognized.

Growth Changes

Growth has been defined as an increase in size, while development is progress towards maturity (Moyers, 1973). The Indian and Caucasian facial skeleton was noted to increase in size with each additional age category. Although a number of the measurements that were used may not have been truly representative of growth per se, they were measurements of the changes of positional relationships of the various component parts of the facial skeleton and denture. Any of the changes that were found in these positional relationships were interpreted as evidence of development or maturation and these differences were tested for significance.

The size of the sample used in any particular growth study is of great importance, as a larger sample becomes more representative of the population as a whole. The difficulty in obtaining longitudinal records of a particular group often makes it difficult to maintain the original sample size. Therefore cross-sectional studies, although being less reliable for growth studies are evaluated to assess the average changes. When the findings of this study disagree with those of other studies, sample size, ethnic differences and the nature of cross-sectional data should be taken into consideration. For example, in cross-sectional studies larger individuals may be selected in one age group while in the following age group the sample may be selected from the opposite extreme, resulting in a conflicting growth trend.

The following morphological differences in the craniofacial region were found to exist between the two populations:

a) Growth Changes in cranial length

Although the anterior cranial length (perpendicular distance from the height of convexity of the glabellar region to the Y-plane was initially larger in the youngest Indian group

(8-13 years), in the control group the anterior cranial length was larger in the oldest subjects (14-18 years). This trend agrees with the findings of Colby (1972), who noted the adult northern Foxe Basin Eskimo had a shorter anterior cranial length than his Caucasian control group. No other comparable cranial length measurements are recorded in the literature for comparison or to use as a precedent.

b) Growth changes in the cranial base

The anterior cranial base was shorter for the Indian group than the control group within each age range studied. In contrast, the Indian was larger ($p < 0.01$) than the control when the posterior cranial base was considered. Bjork (1947) noted that shortening of the anterior cranial base has the effect of increasing facial prognathism. Prior to the serial studies by Bjork (1955) and Coben (1955) the growth and development of the cranial base was rarely discussed. Currently, the cranial base is thought to follow the neural growth curve (Enlow, 1975). The males in the present study were noted to have a consistantly larger anterior cranial base than the females, which could be due to the larger frontal sinus size of the males (Chamma, 1978). Pedersen (1962) noted that in males, the increase in the frontal bone thickness was three times greater than that in females. Since the measurement of the anterior cranial base in this study involved the frontal bone, it is possible that the growth of the frontal bone may have influenced the cranial base measurement.

The Indians displayed an acute cranial base angle which was significantly smaller ($p < 0.05$) than the controls, although this angle was essentially stable over the three age categories in both samples. This observation was similar to that reported by Koski (1960) in a cross-section study of Finnish children. Koski noted the Scandinavian children possessed a prognathic mandible as well as the acute cranial base angle. Koski concluded that because of the cross-sectional nature of the material the cranial base angle was essentially stable as previously demonstrated by others such as Brodie (1953), Bjork (1955) and Ford (1958). Bjork (1947) also has shown that the facial prognathism can be affected by the degree and direction of cranial base flexion. Thus Bjork would consider the Indian group with a more acute cranial base angle to display a greater amount of mandibular prognathism. However, the validity of this statement is presently in question.

c) Growth changes in facial height

The Indian group displayed a greater linear dimension in all variables measured with the exception of the posterior lower face height and the anterior upper face height. The craniofacial measurements of the males were also larger ($p < 0.01$) than the females. The previous observations were all statistically significant. Seal (1957), Helzimmen (1965) and Reed (1968) observed that the males were also larger than the females, regardless of the racial group studied. Hrdlicka (1927, 1931) in an anthropometric study noted the Indian had a larger total face height than that of the Caucasian. Relatively speaking the Indian had a shorter posterior face height than the Caucasian, which may have contributed to the steeper mandibular plane angle. A deficiency of posterior facial growth has been suggested as a cause of the steeper mandibular plane angle (Bjork, 1972).

d) Growth changes of the bony nose

Morphology of the nasal area and the relative prominence of the nose in the profile have been used to characterize the facial phenotypes of many ethnic groups (Comas, 1960). He stated that a straight nasal bridge was found in the South American Indian, a convex bridge in the North American Indian and a concave bridge was characteristic of the Australian aborigine. The supporting structures of the bony nose form the foundation upon which the soft tissue is draped and therefore, directly affects the contours of the soft tissues. The bony nose was noted to be longer, its tip located at a lower level and its profile slightly more prominent in the Indian than the control group.

The development of the Indian bony nose was similar to the longitudinal studies of North American Caucasians by Subtelny (1959) and Posen (1964). There was an increase in length and vertical position of the nasal bones resulting in an increased prominence with age, although no growth spurts were detected. Growth spurts have been reported for nasal growth (Subtelny, 1959) and probably do occur in the Indian, but due to the cross-sectional nature of this study, the relatively wide age ranges and the use of mean figures, these growth spurts may have been obscured.

e) Growth changes of the maxilla

The maxillary length was larger ($p < 0.01$) and the maxilla as a whole was positioned more anteriorly ($p < 0.01$) relative to the anterior cranial base in the Indian group than the control group. An interesting observation was the retrusive relationship of orbitale in the Indian group. This may contribute somewhat to the more prominent nasal complex of the Indian. Regardless of the group structure (Indian or Caucasian) males were larger ($p < 0.05$) than the females.

The maxillary process of the Indian and Caucasian group appeared to translate with age in a downward and forward direction relative to the anterior cranial base. This observation is similar to that described by Broadbent (1937) and Barnes (1954) for the normal growth of the Caucasian. However the angular relationship of the maxillary complex to the anterior cranial base (SNA) remained relatively constant throughout the age range studied. This could be explained by the fact that there could be a similar amount of growth occurring at nasion and point A, that is growth of the anterior cranial base and maxilla was synchronous as previously reported by Ricketts (1961).

A similar degree of maxilla protrusion was noted for American children of Oriental descent by Takano and Wong (1950). Although this similarity may be due to common ancestral relationships, there has no doubt been some environmental influence as well.

f) <u>Growth changes of the mandible</u>

The morphology of the mandible has been reported as being characteristic of many racial groups (Hrdlicka, 1940). In other words, the mandibular form appears to be controlled by genetic factors. The development of the mandible may also be related to function and environment as well as inheritance.

In this investigation the Indian mandible was more prognathic, had a steeper mandibular plane angle to Frankfort Horizontal or sella-nasion and exhibited a more superiorly positioned chin point relative to the mandibular plane than the mandible of the control population. The mandibular length (articulare to pogonion) and the gonial angle were noted to be very similar between the two groups while the ramus length was larger ($p < 0.01$) in the control group. These findings are consistant with those of Hrdlicka (1940) who compared the skulls of numerous North American Indian tribes to those of Caucasians.

The angular measurement SNB and the linear measurements, mandibular length, corpus length and pogonion to mandibular plane increased with age while the angular measurements, gonial angle and mandibular plane to SN decreased with age. These changes have been noted in previous studies of various other facial groups by Hellman (1928), Keen (1945), Bjork (1947), Holzimmer (1965) and Jung (1969). Therefore, the pattern of mandibular growth appears to be similar regardless of race. The decrease in the gonial angle and the mandibular plane angle indicates a possible change in the form of the mandible during its growth period. It may also be related to the increased length of the ramus which would account for the decreased angular relationships.

g) Growth changes of the skeletal profile

The skeletal facial profile of the Indian group exhibited a greater profile convexity than the control group due to the anteriorly placed maxilla. As well there was marked proclination of the maxillary incisor teeth in the Indian group while the mandibular incisors displayed less proclination than the control group. A smaller chin button was also evident in the Indian sample.

It has been shown in previous studies (Corlett, 1947; Schaeffer, 1949; Bjork, 1950 and Baum, 1961) that with age there is a tendency for the incisors to become upright and less prominent in the bony profile. This tendency was demonstrated in the control group, however the Indian group displayed an increase in incisor procumbency. The reason for this is obscure, but it could be due to a variety of reasons. For example, the results could be due to the nature of cross-sectional data or possibly the Indian has less perioral muscle tonicity. Well defined future studies using cephalograms and pressure or force recording devices may elicit information as to the soft tissue differences between the Indian and Caucasian.

The convexity of the skeletal profile of the face generally decreases with age (Bjork, 1947; Subtelny, 1961;

Chaconas, 1975) and the face of the male is usually less convex than the female due to the longer growth period. This allows the male mandible more time for growth in an anterior direction, resulting in a straighter profile. These observations were consistant with those noted in this investigation, although the Indian started and completed growth with a more convex profile.

Evaluation of the cephalometric radiographs revealed that the chin point (pogonion to the N-B line) in the Indian group was small, while that of the Caucasian was acceptably related. The small chin of the Indian was most likely due to the steep mandibular plane angle Schudy (1964) states that the prominence of the chin is disguised by the steepness of the mandibular plane angle. The steeper the mandibular plane the less chin button measurable. Holdaway (1956) states that in "harmonious" Caucasian faces, the measurements "pogonion to NB" and "lower incisor to NB" should be approximately equal and that both pogonion and the lower incisor should be anterior to the NB plane. This relationship of the chin point and mandibular incisors was evident through the age range for the Caucasian while the Indian group did not achieve the accepted relationship. In fact, the relationship of pogonion to the NB line was never greater than 0.8 mm for the Indian group, while that for the Caucasian group was approximately 2 mm. However, the chin did increase in prominence with age for both the Indian and Caucasian sample.

h) Growth changes of the soft tissue profile

The soft tissue profile of the Indian group was more convex and displayed a greater soft tissue thickness in relation to the facial plane than did the control group.

Subtelny (1959) has shown that the soft tissue covering the maxilla increase in thickness and become more convex. while the skeletal framework in this area becomes less convex with age. In this study the soft tissue was noted to increase in thickness with age when measured from the facial plane to soft tissue nasion, nasal tip, upper and lower lip and soft tissue pogonion. However, there was a decrease in the soft tissue angle of convexity (soft tissue nasion - subnasale-soft tissue pogonion) which is consistant with the findings of Chaconas (1975). This decrease is only observed if subnasale is included in the angular measurement rather than the soft tissue nasal tip.

It is obvious that there are some inherent weakness in a study of this type. The purity of the sample could be more definitely ascertained with serological testing. Also whenever a statistical evaluation is undertaken, caution as to the findings must be observed, as this particular tool may be used erroneously. In addition, it is felt that there is a necessity for a larger sample which would be more representative of the population and therefore allow an increase in the accuracy and reliability of the angular and linear measurements studied.

Discriminant Function Analysis

The stepwise discriminant analysis is a traditional method of studying differences in the distribution of cranio-facial variables in distinct groups of individuals (Howells, 1972, 1973). This analysis was applied to the twenty-eight variables choosen from the univariate analysis as described by Huberty (1975), in order to ascertain the contribution of each variable and the order of their importance in an attempt to maximize the difference between the groups. The importance of the variables choosen by the discriminant function is determined by their order of selection, with the most discriminating selected earliest. One would expect to economize the number of variables required to separate the groups by including in the discriminant function only those variables which significantly add to the discriminating power of the function.

The results of the step-wise discriminant analyses comparing the racial groups were presented in Table V. The variables listed in this table represent the most discriminating of the twenty-eight measurements selected from the univariate analysis. Correct identification was found to be more accurate for the Indian group than the control sample. It is therefore conceivable that the Indian sample may be of a more homogeneous nature than the Caucasian sample. This was confirmed by the smaller standard deviation of the Indian group. This observation could also be interpreted as proof that this particular Indian group is of a more homogeneous nature than many anthropologists believe.

The six discriminant function analyses exhibited a number of variables that contributed to three or more of the analyses with two consistantly contributing significantly to each analysis. These two were the angular relationship of orbitale to SN (smaller in the Indian) and the linear measurement, vertical height of pogonion in relation to the mandibular plane (longer in the Indian). Colby (1972) noted the same two variables to be significantly different in the Eskimo and Caucasian samples. Perhaps this similarity of the Indian and Eskimo craniofacial patterns is due to their proposed common ancestry (Laughlin, 1967). Further investigation using data obtained from an Indian, Eskimo and Caucasian sample could reveal interesting information concerning the similarities and differences of these groups. For example, the Indian and Eskimo may have a more closed, upright cranial base flexure and shorter anterior cranial base which usually characterizes the brachycephalic head. These similarities may be due to genetic factors due to their common ancestry. The various measurements of the lower jaw may also display significant discriminating powers.

Kowalski (1975) subjected data obtained from adult Sioux Indians and adult Caucasians to a discriminant function analysis and found that the relationship of the lower incisor to the NB line was the single best discriminator. This angular relationship of the lower incisor to the NB line was also noted in the present investigation to be one of the best discriminators between the Indian and Caucasian groups. In the present study the Indian group had a less protrusive lower incisor than the Caucasian group.

The differences in craniofacial morphology between the racial groups studied are clearly demonstrated in Figures 41 - 46. These figures also demonstrate that the craniofacial skeleton becomes less variable with age, as the older age groups can be more accurately predicted by the Jackknife technique.

Utilizing the data obtained, it would be interesting to perform this discriminant analysis on a number of skulls from various burial grounds around the Winnipeg River system. This could aid in determining the identity of particular Indian tribes as well as various migrations. For example this type of discriminant analysis could possibly distinguish between Ojibwa or Caucasian skulls discovered in the area.

The implications of this type of analysis for future research on living or burial samples are twofold. First, the results of this study demonstrate the power of the discriminant function analysis to differentiate between racial groups. Second, by defining the craniofacial pattern of the Ojibwa Indian, a testable pattern has been established for future studies. These results may be utilized by researchers in other disciplines, such as archaeology and physical anthropology.

Acceptable Occlusion Group

In this country, as well as in other countries, the services of orthodontists are being sought by more people each year. Perhaps, this is due to the advancement in dental health education and the rise in the standard of living. The improvement not only in facial esthetics but more importantly function of the stomatognathic system that may result from orthodontic treatment is now recognized. More people are also becoming more aware of the damaging effects that malocclusion may have on the periodontium and its adverse effect on the longevity of the dentition. In view of this increased awareness of orthodontic therapy treatment norms have been developed so as to be useful for orthodontic diagnosis and treatment planning of the North American Indian child living on the Peguis Reserve.

Previous studies (Bjork, 1949; Cotton, 1950; Altemus, 1960; Smith, 1970; Kowalski, 1975; Iwasawa, 1977) have shown definite differences in various racial groups and therefore, a need was felt to exist for an analysis based on an investigation of a sample from this particular Indian group.

> "The human races may be divided into broad groups which are distinguishable one from another by certain positive though not always constant factors. The deviation from these constants are due to various causes, the most important and powerful factor being the mingling of one or more types of different divisions. Where different races have intermarried, the offspring may take on the characteristics of either parent or there may be mingling of both and the consequent resultant becomes a conglomerate type which is not always easy to classify.

> Any scientist who, however remotely, has to do with changing the relative proportions and positions of the feature of the human being, should pause and study well the type to which this face belongs and should use every possible means to retain that type".

These thoughts of Wuerpel (1937) illustrate an additional motivating force in a study of this type. Cephalometrics may be used to compare the "normal" with the "abnormal" and pre-treatment with post-treatment, but the evident differences of the various racial groups certainly play a major role in diagnosis and treatment planning. The fact that the radiographic cephalometric investigations have become commom place in orthodontic literature, yet few of these studies have been concerned with the North American Indian was in part a reason for this study.

The Indian children selected from the Peguis Indian Reserve for this aspect of the study possessed an Angle Class I molar relationship, an acceptable overjet and overbite, no missing teeth, minimal rotations and no history of orthodontic therapy. This group was termed the "acceptable" occlusion group.

In order to compare the observations in the present study of the acceptable occlusion group with the standards or norms for Caucasians, as well as other racial groups, the means and standard deviations for each linear and angular measurement were obtained.

The Downs analysis has been frequently employed to establish standards for various racial groups. It was therefore used as a means to compare the results of this investigation with the results of other racial groups studied. These groups include the Caucasian (Downs, 1948), Chinese (Wong, 1950), Japanese (Takano, 1950), Negro (Altemus, 1960) and Phillippino (Sabater, 1969). These particular investigations were selected as their samples were chosen using similar criteria to that used in the present study.

A comparison of the mean facial angle for the above racial groups showed a small range between the groups (84.9^o - 88.5^o) with the exception of the Chinese. The Chinese possess the most retrognathic chin (77.5^o), the Japanese the most prognathic chin (88.5^o) and the North American Indian lies midway between these two extremes (84.9^o).

Examination of the angle of convexity revealed that the Negro (9.7^o) and North American Indian (9.5^o) exhibited the greatest convexity both due to maxillary protrusion while the Caucasian (0^o) displayed the straighest profile. The Japanese (3.6^o) and the Phillippino (4.7^o) showed a mild convex appearance.

A very close similarity of the mean A-B plane angle (-3.7^o - -7.7^o) was noted among the groups. The Phillippino group showed the smallest A-B plane angle (-3.7^o) while the Negro had the largest (-7.7^o), followed closely by the Indian sample (-7^o).

The mean readings for the mandibular plane angle to Frankfort Horizontal showed that the Chinese (32.4^o) and the North American Indian (31.5^o) have the highest mandibular plane angle. This could be expected as the Chinese next to the Indian presented the smallest mean facial angle indicating a more retrognathic chin. The Caucasians exhibited the "flattest" mandibular plane angle (21.9^{o}) while the Negro (28.8^{o}) and the Phillippino (28.7^{o}) had approximately the same angulation.

The Chinese (67.1^{o}) exhibited the greatest mean Y-axis angle (which is a further indication of a more retrognathic mandible), while the Caucasian (59.4^{o}) showed the smallest mean Y-axis angle. The Phillippino (65.0^{o}), Negro (63.4^{o}), Indian (62.7^{o}) and Japanese (62.1^{o}) groups were intermediate.

The mean readings for the occlusal plane to Frankfort Horizontal were essentially the same in all groups (8.3^{o} - 11.8^{o}) except for the Chinese (16.9^{o}), who presented the largest cant of the occlusal plane.

The mean interincisal angle was largest in the Caucasian (135.4^{o}), indicating a more upright position of the incisor teeth to each other. The Indian (126.8^{o}) and Japanese (126.4^{o}) were midway between the extremes with the Negro having the most procumbent incisors (119.2^{o}).

A comparison of the mean lower incisor to the occlusal plane showed the Negro group exhibited the greatest proclination of the lower incisors to their functioning surfaces (functional occlusal plane). The Indians (13.0^{o}) and Caucasians (14.5^{o}) revealed a more upright lower incisor while the Phillippino (24.0^{o}), Chinese (22.2^{o}) and Japanese (21.5^{o}) were intermediate to the Indian and Negro groups.

The comparison of the mean angulation of the lower incisor to mandibular plane revealed a similar angulation. The

Caucasian incisors (1.4°) were the most upright while the Negro (9.8°) displayed the greatest proclination of the mandibular incisors. The Indian (4.6°) was between these two extremes.

The mean values for the upper incisor to A-P plane were greatest in the Negro (10.4 mm) followed closely by the Philippino (8.6 mm) indicating a more forward location of the upper incisors in these two groups. The Caucasian (2.7 mm) showed the smallest mean upper incisor to A-P plane while the Chinese (7.6mm), Japanese (6.6 mm) and the North American Indian (5.5 mm) had essentially the same values.

From the Downs analysis it was noted that the Indian demonstrated a more convex profile and proclined maxillary and mandibular incisors in comparison to the very straight profile and upright incisors of the Caucasians. In contrast the Indian possessed a straighter profile and more upright incisors compared to the Negro's bimaxillary protrusion.

Comparisons of Indians and controls using the Manitoba Analysis (Table IX) revealed a similarity between the Indian with an acceptable occlusion living on the Peguis Indian Reserve and the Caucasian with an acceptable occlusion living in the Winnipeg area. Teal (1953) compared Navajo Indians and Caucasians with acceptable occlusions and noted the Navajo face to the "balanced" and not too different from the Caucasian face. The similarity in the present study could possibly be due to the fact that there may have been intermarriage between the Indian group and the Selkirk Settlers

(Hallowell, 1955; Steinbring, 1972). It has also been proposed that a particular skeletal pattern is more conducive to an acceptable occlusion (Christie, 1977). Since the two samples were chosen on the basis of an acceptable occlusion, the similar skeletal pattern could possibly have been expected. Christie states that people with normal occlusion tend to have more brachyfacial than dolicofacial patterns. Unfortunately posterior-anterior (P-A) radiographs were not obtained in order to assess this particular aspect of the Indian sample. It would be of interest to see if all the Indian sample has a brachyfacial pattern or whether it was just the acceptable occlusion group that possessed this particular form. A further study involving P-A radiographs could be very informative in other aspects as well. For example, an assessment of asymmetry could be performed, thereby allowing the results of the Caucasian study (Chamma, 1978) to be compared to the Indian to determine if similar patterns exist. Chamma noted that the left side of the skull was larger in both Caucasian males and females. The P-A radiographs could also be used in implementing a three-dimensional study of the Indian.

Further study of this particular tribe could encompass frontal and profile photographs of a number of the Indian subjects. These photographs could be used to determine what the Indian considers the most beautiful and properly proportioned face. These faces could then be subject to close scrutinity using lateral cephalometric radiographs. This would result in cephalometric ideals for the

Indian face.

Maturity Assessment of the Indian Sample

No assumptions were made about the results of the ninety-four hand-wrist films. Three possibilities existed for the relationship between skeletal age and chronologic age. That is, the skeletal age could be greater than, less than or equal to the chronological age. The results could possibly be explained by dietary practices. For example, if the skeletal age is retarded compared to the chronological age, then this might be partially explained by a poorly balanced diet (Moore, 1974). Unfortunately, no exact data have been gathered on dietary practices of the Peguis Indian Reserve.

The fact that the skeletal age was slightly retarded or similar to the chronological age in many instances is most likely due to the interaction of many factors. Bayley (1959) states that an average skeletal age is considered to be one in which the skeletal age is within one year of the chronological age. About two-thirds of a healthy population of children will have skeletal ages that are no more than a year above or below their chronological age. Therefore, on this basis, the chronological and skeletal ages are acceptable for this particular Indian group.

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

The present cephalometric investigation was undertaken to determine the normal range and variation that constitutes the facial skeleton of the North American Indian child living on the Peguis Indian Reserve in Manitoba and to determine if these measurements are statistically different from those of Winnipeg Caucasian children. Univariate and multivariate analysis of all the Indian and Caucasian group, a cephalometric assessment of an acceptable occlusion group, as well as an analysis of hand-wrist radiographs of the Indian group were utilized to determine these differences.

The test sample comprised 114 Indian children residing on the Peguis Indian Reserve and the control sample of 163 Caucasians living in and around Metropolitan Winnipeg. The ages ranged from 8-18 years in both the Indian and control samples: both samples were grouped according to sex and age.

Linear and angular measurements obtained from the lateral cephalometric radiographs were used to evaluate and compare the two populations. The results of the univariate analysis, discriminant function analysis, acceptable occlusion assessment and the analysis of the hand-wrist films warrant the following conclusions:

1) The linear measurements of the Indian group were larger than the control group, indicating that the overall size of the

craniofacial complex was greater in the Indian than in the Caucasian group for all age categories.

2) There was a trend towards sexual dimorphism with the males generally larger than the females.

3) The Indians displayed a more anteriorly positioned maxilla, steeper mandibular plane (to sella-nasion or Frankfort Horizontal) and protrusive maxillary incisors. The Indian group may also be described as having a convex mesognathic profile with the skeletal chin point in harmony with the face.

4) The six discriminant function analyses revealed that the best discriminators were the relationship of orbitale to SN, the vertical height of pogonion in relation to the mandibular plane and the relationship of the lower incisor to NB.

5) The discriminant analyses revealed that the Indian sample was more homogeneous than the control group.

6) The skeletal and dental patterns of the Indian and Caucasian acceptable occlusion groups were very similar with the exception of the steeper mandibular plane angle and the more protrusive maxilla of the Indian.

7) The cephalometric norms of the Manitoba analysis are applicable to the Indian child living on the Peguis Indian Reserve.

8) Although the skeletal age of the Indian sample was slightly retarded in relation to the chronologic age, the fact that the skeletal age was generally within one year of the chronologic age, warrants the conclusion that there was an acceptable chronologic/skeletal age relationship in the Indian group.

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APPENDIX

APPENDIX I

GLOSSARY OF LANDMARKS AND PLANES

I. LANDMARKS

1. Machine Porion

The most superior point on the ear rods of the cephalostat and believed to represent the mid-point on the upper edge of the external auditory meatus.

2. Sella (s)

The centre of the sella turcica (pituitary fossa)

3. Frontale

The most anterior point on the frontal bone determined by a perpendicular line from the SN line.

4. Nasion

The mid-point of the fronto-nasal suture at its most anterior margin.

5. Nasal tip

The most anterior inferior point on the nasal bone.

6. Orbitale

The deepest point on the infra-orbital margin of the bony orbit (bisected).

7. Soft Tissue Nasion

The most anterior point on the soft tissue nose parallel to nasion.

8. Pronasale

The most anterior point on the contour of the soft tissue nose as measured from the N-Pog line.

9. Soft Tissue "A" Point

The most posterior point of the philtrum of the upper lip.

10. Labrale Superius

The most prominent point on the upper lip measured perpendicular to the N-Pog line.

11. Stomion

The lowest point on the upper lip and the highest point on the lower lip.

12. Labrale Inferius

The most prominent point on the lower lip measured perpendicular to the N-Pog line.

13. Soft Tissue "B" Point

The most posterior point on the contour between the labrale inferius and the soft tissue pogonion.

14. Soft Tissue Pogonion

The most prominent point on the contour of the soft tissue covering of the chin.

15. Menton

The most inferior point on the symphysis menti of the mandible.

16. Gnathion

The most anterior and inferior point on the contour of the chin.

17. Pogonion

The most anterior point on the contour of the chin.

18. "B" Point

The deepest point on the midline contour of the mandible between infra-dentale and pogonion.

19. The apex of the mandibular left central incisor.

20. The incisal edge of the maxillary left central incisor.

21. The incisal edge of the mandibular left central incisor.

22. The apex of the maxillary left central incisor.

23. "A" Point

The deepest point on the midline contour at the alveolar process between the anterior nasal spine and the alveolar crest of the maxillary central incisor.

24. Anterior Nasal Spine (ANS)

The median, sharp bony process of the maxilla at the lower margin of the anterior nasal opening.

25. Posterior Nasal Spine (PNS)

The process formed by the united projecting ends of the posterior borders of the palatal processes of the palatal bones.

26. Pterygomaxillary Fissure (PTM)

The projected contour of the fissure formed by the anterior curvature of the pterygoid process and the posterior wall of the tuberosity of the maxilla. The cephalometric radiographic point is the most posterior point on the posterior wall of the maxillary tuberosity.

27. Articulare (Ar)

The point of intersection of the external dorsal contour of the mandibular condyle and the temporal bone. The midpoint is used when the profile radiograph shows double projections of the rami.

28. Condylion

The most superior and posterior point on the mandibular condyle.

29. Basion (Ba)

The most forward and lowest point on the anterior margin of the foramen magnum.

30. Distobuccal cusp tip of the maxillary left first molar.

31. Distobuccal cusp tip of the mandibular left first molar.

32. The most inferior point on the posterior one-third of the lower border of the mandible.

33. Gonion (Go)

The lowest most posterior, and the most outward point on the angle of the mandibular base line and the line tangent to the posterior border of the ramus.

II. PLANES

1. Sella-Nasion (SN) - A line connecting points sella and nasion.

2. Frankfort Horizontal (FH) - A line extending from the cephalometric porion to orbitale.

3. Palatal Plane (PP) - On the initial radiograph a line connecting anterior and posterior nasal spine and extending to include the transfer points 34 and 35.

4. Occlusal Plane (OP) - A line connecting the distobuccal cusp of the lower first permanent molar to the incisal edge of the mandibular central incisors.

5. Mandibular Plane (MP) - A line tangent to the inferior border of the mandible from menton to gonion.

6. Facial Plane (FP) - A line from nasion to pogonion.

APPENDIX II

Linear Measurements

1. 24-25: Maxillary palatal plane length which includes the length of the maxilla and the palatal bones (Figures 11).
2. 4-5: The length of the nasal bone (Figure 11).
3. 27-17: The length of the mandible from articulare to pogonion (Figure 11).
4. 2-29: Length of the posterior cranial base (Figure 11).
5. 33-17: The corpus length of the mandible (Figure 12).
6. 28-16: The total mandibular length from condylion to gnathion (Figure 11).
7. 8- Facial plane (4-17): The horizontal development of the soft tissue nose in relation to the anterior facial plane (Figure 15).
8. 10-Facial plane (4-17): The horizontal development of the upper lip in relation to the anterior facial plane (Figure 15).
9. 12-Facial plane (4-17): The horizontal development of the lower lip in relation to the anterior facial plane (Figure 15).
10. 14-Facial plane (4-17): The horizontal development of the soft tissue chin point in relation to the anterior facial plane (Figure 15).
11. 17-Mandibular plane (32-15): The vertical height of the anterior limit of the mandible (chin point) in relation to the mandibular plane (Figure 11).

12. 20-Facial plane (4-17): The horizontal position of the upper incisors in relation to the anterior facial plane.
13. 21-Facial plane (4-17): The horizontal position of the lower incisors in relation to the anterior facial plane.
14. 2-4: The development of the anterior cranial base (Figure 11).
15. 3-Y-plane: The development of the anterior cranial base and the glabella region in an anterior direction (Figure 12).
16. 5-SN plane (2-4): The vertical distance that the tip of the nasal bone lies below the anterior cranial base (Figure 12).
17. 3-SN plane (2-4): The height of the convexity of the frontal bone in relation to the anterior cranial base (Figure 12).
18. 4-24: The vertical height of the anterior limit of the maxilla and in addition may mark the lowest point on the nasal cavity floor (Posen 1964) (Figure 12).
19. 4-15: The vertical height of the anterior portion of the face in relation to the anterior cranial base and is indicative of total anterior facial development (Figure 12).
20. 24-15: The lower face height measured from the anterior nasal spine to menton (Figure 12).
21. 32-2: The vertical height of the posterior face in relation to the anterior cranial base (Figure 13).

22. 2-27: The posterior upper face height (Figure 13).

23. 27-32: The posterior lower face height (Figure 13).

24. 20-21: The overjet when measured parallel to the palatal plane.

25. 20-21: The overbite when measured perpendicular to the palatal plane.

26. 27-Mandibular plane (15-32): The length of the ramus from articular to gonion (Figure 11).

27. 20-A-P plane (17-23): The relationship of the maxillary incisor to the skeletal profile.

28. 21-A-P plane (17-23): The relationship of the mandibular incisor to the skeletal profile.

29. 30-20: The length of the maxillary dental arch from the disto-buccal cusp of the 1st molar to the central incisor (Figure 14).

30. 31-21: The length of the mandibular dental arch from the disto-buccal cusp of the lower 1st molar to the lower central incisor (Figure 11).

31. 30-Palatal plane (25-24): The dental alveolar development of the maxillary 1st molar in relation to the palatal plane (Figure 13).

32. 20-Palatal plane (25-24): The dental alveolar development of the maxillary central incisor in relation to the palatal plane (Figure 13).

33. 21-Mandibular plane (32-15): The dental alveolar development of the mandibular incisor in relation to the mandibular plane (Figure 13).

35. 12-"E" Line (14-8): The anterior-posterior position of the lower lip in relation to the soft tissue profile. (A measure of the relative procumbancy of the lips) (Figure 15).

36. 10-"E" Line (14-8): The antero-posterior position of the upper lip in relation to the soft tissue profile (Figure 15).

37. 20-NA Plane (4-23): The linear relationship of the maxillary incisor to the line joining nasion and point A. This is a measure of the A-P position of the incisor.

38. 21-NB Plane (4-18): The linear relationship of the mandibular incisor to the line joining nasion and point B. This is a measure of the A-P position of the incisor.

39. P to NB (17 to 4-18): The effective chin button in relationship to the NB line.

40. 28-17 (measured along mandibular plane): The total mandibular length from condylion to pogonion according to Wylie's method (Figure 14).

41. 2-28 (measured along Frankfort Horizontal): The anterior posterior position of the condyle in relation to sella (Figure 14).

42. 2-26 (measured along Frankfort Horizontal): The anterio-posterior position of the dorsal level of the maxilla in relation to sella (Figure 14).

43. 26-24 (measured along Frankfort Horizontal): The total length of the maxilla (Figure 14).

44. 26-30 (measured along the Frankfort Horizontal): The anterio-posterior position of the buccal segment of the maxillary denture (Figure 14).

Angular Measurements

45. Facial Angle: An expression of the degree of recession or protrusion of the chin and is used in typing faces as retrognathic, orthognathic prognathic (Angle 1, Figure 17).

46. Angle of Convexity: The anterior limit of the maxilla in the profile with point A as the vertex of an angle formed by the NA line and the AP line. This angle is recorded as a plus if A point is anterior to the facial plane and minus if it is posterior (Angle 2, Figure 16).

47. SNA: The relationship of the maxillary apical base to the anterior cranial base (Angle 3, Figure 16).

48. SNB: The angle relates the mandibular apical base to the anterior cranial base (Angle 4, Figure 17).

50. Mandibular Plane Angle: Relates the inferior border of the mandible to the Frankfort Horizontal. Changes in this angle may reflect acceleration or retardation of vertical development of either the anterior or posterior aspects of the mandible (Angle 6, Figure 17).

51. Interincisal Angle: A measure of the degree of procumbency of the incisor teeth (Angle 7, Figure 18).

52. UI to SN: Relates the maxillary incisor to the anterior cranial base and is a measure of the proclination of the maxillary incisors (Angle 8, Figure 18).

53. LI to MP: Relates the lower incisor to the mandibular plane (Angle 9, Figure 18).

54. 29-2-4: Relates the anterior and posterior cranial base (Angle 10, Figure 16).

55. 5-4-17: Relates the nasal bone to the anterior facial plane (Angle 11, Figure 17).

56. 5-4-2: Relates the nasal bone to the anterior cranial base (Angle 12, Figure 17).

57. Mandibular Plane to SN: Relates the inferior border of the mandible to the anterior cranial base (Angle 13, Figure 17).

58. Palatal Plane to SN: Relates the maxilla to the anterior cranial base. Changes in this angle may reflect differences in the relative vertical development of the anterior and posterior nasal spines (Angle 14, Figure 16).

59. Ramus Line to Mandibular Plane: Represents the gonial angle and relates the ramus to the body of the mandible (Angle 15, Figure 18).

60. 2-4-17: Relates the anterior limit of the mandible (chin point) to the anterior cranial base (Angle 16, Figure 17).

61. Y-Axis Angle: This angle is formed by the intersection of a line from 2 to 16 and the Frankfort Horizontal plane and is used as an expression of the direction of growth of the mandible (Angle 17, Figure 17).

62. A-B Plane Angle: The location of this plane in relation to the facial plane is a measure of the relation of the anterior limit of the denture bases to each other and the profile (Angle 18, Figure 19).

63. 7-8-14: Represents the overall soft tissue contour including the tip of the nose (Angle 19, Figure 19).

64. 7-9-14: Represents the anterior limit of subnasale (9) in the profile and is a measure of the soft tissue angle of convexity (Angle 20, Figure 19).

65. 6-SN Plane: Records the relationship of orbitale to SN and is a measure of the degree of retrusion of orbitale (Angle 21, Figure 19).

66. FMIA: Frankfort mandibular incisor angle. This measures the procumbency of the mandibular incisor to the Frankfort plane (Angle 22, Figure 18).

67. UI to NA: Records the relationship of the maxillary incisor to the line from nasion to A point and is a measure of the proclination of the maxillary incisors (Angle 23, Figure 18).

68. LI to NB: Records the relationship of the mandibular incisor to the line NB and is a measure of the proclination of the mandibular incisors (Angle 24, Figure 16).

69. Palatal Plane to Mandibular Plane: Records the relationship of the palatal plane to the mandibular plane (Angle 25, Figure 16).

70. Occlusal Plane to Palatal Plane: Records the relationship of the mandibular occlusal plane to the palatal plane (Angle 26, Figure 19).

71. Occlusal Plane to Frankfort Horizontal: Records the cant of the mandibular occlusal plane in relationship to the Frankfort Horizontal (Angle 27, Figure 19).

72. LI to Occlusal Plane: Relates the incisors to their functioning surface at the occlusal plane (Angle 28, Figure 19).

APPENDIX III

Variables employed to establish the Growth Trends

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1. 24-24: Maxillary palatal plane length which includes the length of the maxilla and the palatal bones (Figure 11).
2. 4-5: The length of the nasal bone (Figure 11).
3. 27-17: The length of the mandible from articulate to pogonion (Figure 11).
4. 2-29: Length of the posterior cranial base (Figure 11).
5. 33-17: The corpus length of the mandible (Figure 12).
7. 8-Facial plane (4-17): The horizontal development of the soft tissue nose in relation to the anterior facial plane (Figure 15).
8. 10-Facial Plane: The horizontal development of the upper lip in relation to the anterior facial plane (Figure 15).
9. 12-Facial Plane: The horizontal development of the lower lip in relation to the anterior facial plaque (Figure 15).
10. 14-Facial Plane: The horizontal development of the soft tissue chin point in relation to the anterior facial plane (Figure 15).
11. 17-Mandibular Plane (32-15): The vertical height of the anterior limit of the mandible (chin point) in relation to the mandibular plane (Figure 11).

14. 2-4: The development of the anterior cranial base (Figure 11).

15. 3-Y Plane: The development of the anterior cranial base and the glabella region in anterior direction (Figure 12).

16. 5-SN Plane: The vertical distance that the tip of the nasal bone lies below the anterior cranial base (Figure 12).

17. 3-SN Plane: The height of the convexity of the frontal bone in relation to the anterior cranial base (Figure 12).

18. 4-24: The vertical height of the anterior limit of the maxilla and in addition may mark the lowest point on the nasal cavity floor (Posen, 1964) (Figure 12).

19. 4-15: The vertical height of the anterior portion of the face in relation to the anterior cranial base and is indicative of total anterior facial development (Figure 12).

20. 24-15: The lower face height measured from the anterior nasal spine to menton (Figure 12).

21. 32-2: The vertical height of the posterior face in relation to the anterior cranial base (Figure 13).

22. 2-27: The posterior upper face height (Figure 13).

23. 27-32: The posterior lower face height (Figure 13).

26. 27-Mandibular Plane: The length of the ramus from articular to gonion (Figure 11).

27. 20-A-P Plane: The relationship of the maxillary incisor to the skeletal profile.

28. 21-A-P Plane: The relationship of the mandibular incisor to the skeletal profile.

39. P to NB: The effective chin button in relationship to the NB line.

46. Angle of Convexity: The anterior limit of the maxilla in the profile with point A as the vertex of an angle formed by the NA line and the AP line. This angle is recorded as a plus if A point is anterior to the facial plane and minus if it is posterior (Angle 2, Figure 16).

47. SNA: The relationship of the maxillary apical base to the anterior cranial base (Angle 5, Figure 16).

48. SNB: The angle relates the mandibular apical base to the anterior cranial base (Angle 4, Figure 17).

49. ANB: Relates the anterior limits of the maxillary and mandibular apical bases to each other (Angle 5).

53. LI to MP: Relates the lower incisor to the mandibular plane (Angle 9, Figure 18).

54. 29-2-4: Relates the anterior and posterior cranial base (Angle 10, Figure 16).

55. 5-4-17: Relates the nasal bone to the anterior facial plane (Angle 11, Figure 17).

56. 5-4-2: Relates the nasal bone to the anterior cranial base (Angle 12, Figure 17).

57. Mandibular Plane to SN: Relates the inferior border of the mandible to the anterior cranial base (Angle 13, Figure 17).

58. Palatal Plane to SN: Relates the maxilla to the anterior cranial base. Changes in this angle may reflect differences in the relative vertical development of the anterior and posterior nasal spines (Angle 14, Figure 16).

59. Ramus line to Mandibular Plane: Represents the gonial angle and relates the ramus to the body of the mandible (Angle 15, Figure 18).

60. 2-4-17: Relates the anterior limit of the mandible (chin point) to the anterior cranial base (Angle 16, Figure 17).

63. 7-8-14: Represents the overall soft tissue contour including the tip of the nose (Angle 19, Figure 19).

64. 7-9-14: Represents the anterior limit of subnasale (9) in the profile and is a measure of the soft tissue angle of convexity (Angle 20, Figure 19).

65. 6-SN Plane: Records the relationships of orbitale to SN and is a measure of the degree of retrusion of orbitale (Angle 21, Figure 19).

Appendix IV

Table XI

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Variables 1 - 72)

	Indian		Control	
Age Group	Male	Female	Male	Female
	1. Maxillary Palatal Plane Length (cm)			
8 - 11	4.89 ± 0.03	4.80 ± 0.05	4.66 ± 0.08	4.53 ± 0.04
12 - 13	4.93 ± 0.05	4.95 ± 0.08	4.68 ± 0.09	4.67 ± 0.06
14 - 18	5.12 ± 0.09	4.95 ± 0.09	5.08 ± 0.06	4.88 ± 0.06
	2. Nasal Bone Length (cm)			
8 - 11	2.32 ± 0.05	2.32 ± 0.06	2.01 ± 0.04	2.02 ± 0.03
12 - 13	2.34 ± 0.06	2.34 ± 0.06	2.19 ± 0.04	2.26 ± 0.05
14 - 18	2.46 ± 0.12	2.32 ± 0.04	2.18 ± 0.06	2.20 ± 0.05
	3. Mandibular Length: 27-17 (cm)			
8 - 11	9.51 ± 0.09	9.29 ± 0.08	9.47 ± 0.13	9.14 ± 0.09
12 - 13	9.92 ± 0.08	9.92 ± 0.09	9.90 ± 0.10	9.83 ± 0.09
14 - 18	10.22 ± 0.14	10.05 ± 0.08	10.50 ± 0.15	9.84 ± 0.20
	4. Posterior Cranial Base Length (cm)			
8 - 11	4.32 ± 0.07	4.17 ± 0.04	4.09 ± 0.07	3.98 ± 0.04
12 - 13	4.41 ± 0.05	4.42 ± 0.04	4.32 ± 0.03	4.30 ± 0.04
14 - 18	4.68 ± 0.08	4.38 ± 0.06	4.30 ± 0.06	4.06 ± 0.05

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	5. Corpus Length of the Mandibule (cm)			
8 - 11	7.48 ± 0.09	7.36 ± 0.06	7.34 ± 0.10	7.14 ± 0.09
12 - 13	7.84 ± 0.06	7.86 ± 0.08	7.73 ± 0.08	7.77 ± 0.08
14 - 18	8.12 ± 0.10	7.85 ± 0.14	8.17 ± 0.10	7.79 ± 0.09
	6. Mandibular Length: 28-16 (cm)			
8 - 11	10.37 ± 0.11	10.18 ± 0.08	9.74 ± 0.16	9.47 ± 0.23
12 - 13	10.79 ± 0.09	10.79 ± 0.10	10.50 ± 0.20	10.59 ± 0.13
14 - 18	11.22 ± 0.17	10.81 ± 0.23	11.28 ± 0.23	10.77 ± 0.11
	7. 8 - Facial Plane (cm)			
8 - 11	2.78 ± 0.06	2.77 ± 0.04	2.61 ± 0.09	2.67 ± 0.05
12 - 13	2.74 ± 0.05	2.86 ± 0.04	3.01 ± 0.04	2.92 ± 0.04
14 - 18	3.05 ± 0.08	2.91 ± 0.07	3.20 ± 0.06	3.04 ± 0.08
	8. 10 - Facial Plane (cm)			
8 - 11	2.09 ± 0.07	2.09 ± 0.06	1.89 ± 0.06	1.83 ± 0.06
12 - 13	2.06 ± 0.06	2.07 ± 0.04	1.99 ± 0.05	1.85 ± 0.03
14 - 18	2.33 ± 0.07	1.99 ± 0.04	2.06 ± 0.06	1.90 ± 0.06

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	9. 12 - Facial Plane (cm)			
8 - 11	1.87 ± 0.08	1.78 ± 0.05	1.71 ± 0.06	1.58 ± 0.05
12 - 13	1.85 ± 0.05	1.81 ± 0.05	1.75 ± 0.05	1.63 ± 0.04
14 - 18	2.05 ± 0.05	1.74 ± 0.06	1.77 ± 0.05	1.70 ± 0.06
	10. 14 - Facial Plane (cm)			
8 - 11	1.20 ± 0.05	1.15 ± 0.04	1.01 ± 0.04	0.96 ± 0.02
12 - 13	1.19 ± 0.05	1.19 ± 0.03	1.20 ± 0.04	1.17 ± 0.03
14 - 18	1.28 ± 0.05	1.34 ± 0.06	1.18 ± 0.05	1.17 ± 0.03
	11. Pogonion - Mandibular Plane (cm)			
8 - 11	0.93 ± 0.03	0.92 ± 0.03	0.70 ± 0.03	0.65 ± 0.02
12 - 13	1.01 ± 0.03	0.97 ± 0.03	0.68 ± 0.04	0.73 ± 0.03
14 - 18	1.11 ± 0.06	1.07 ± 0.04	0.84 ± 0.02	0.80 ± 0.03
	12. Upper Incisor - Facial Plane (cm)			
8 - 11	0.88 ± 0.06	0.88 ± 0.04	0.45 ± 0.07	0.39 ± 0.05
12 - 13	0.78 ± 0.06	0.81 ± 0.07	0.46 ± 0.06	0.51 ± 0.05
14 - 18	0.99 ± 0.04	0.70 ± 0.07	0.39 ± 0.06	0.60 ± 0.06

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	13. Lower Incisor - Facial Plane (cm)			
8 - 11	0.50 ± 0.05	0.57 ± 0.04	0.47 ± 0.07	0.57 ± 0.06
12 - 13	0.50 ± 0.05	0.52 ± 0.06	0.55 ± 0.07	0.55 ± 0.06
14 - 18	0.64 ± 0.05	0.49 ± 0.09	0.35 ± 0.08	0.39 ± 0.07
	14. Anterior Cranial Base Length (cm)			
8 - 11	6.63 ± 0.05	6.37 ± 0.04	6.48 ± 0.07	6.35 ± 0.05
12 - 13	6.58 ± 0.06	6.44 ± 0.07	6.64 ± 0.05	6.53 ± 0.04
14 - 18	6.74 ± 0.10	6.60 ± 0.09	6.96 ± 0.08	6.63 ± 0.05
	15. Glabella - Y Plane (cm)			
8 - 11	7.20 ± 0.05	6.95 ± 0.06	6.99 ± 0.07	6.79 ± 0.06
12 - 13	7.15 ± 0.07	6.91 ± 0.07	7.05 ± 0.06	7.03 ± 0.06
14 - 18	7.25 ± 0.09	7.21 ± 0.12	7.46 ± 0.08	7.14 ± 0.06
	16. 5 - SN Plane (cm)			
8 - 11	2.18 ± 0.05	2.17 ± 0.07	1.89 ± 0.04	1.89 ± 0.03
12 - 13	2.18 ± 0.05	2.08 ± 0.07	2.00 ± 0.04	2.10 ± 0.05
14 - 18	2.18 ± 0.10	2.10 ± 0.06	1.98 ± 0.06	1.97 ± 0.05

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	17. Glabella - SN Plane (cm)			
8 - 11	1.44 ± 0.14	1.61 ± 0.07	1.09 ± 0.05	0.97 ± 0.03
12 - 13	1.55 ± 0.07	1.48 ± 0.06	1.00 ± 0.05	1.28 ± 0.10
14 - 18	1.63 ± 0.12	1.62 ± 0.14	1.00 ± 0.03	1.04 ± 0.04
	18. Upper Face Height (cm)			
8 - 11	4.94 ± 0.07	4.85 ± 0.05	4.84 ± 0.08	4.74 ± 0.05
12 - 13	5.18 ± 0.06	5.01 ± 0.05	5.22 ± 0.05	5.22 ± 0.06
14 - 18	5.21 ± 0.10	5.18 ± 0.08	5.49 ± 0.09	5.20 ± 0.04
	19. Total Face Height (cm)			
8 - 11	11.73 ± 0.12	11.40 ± 0.11	11.10 ± 0.17	10.83 ± 0.10
12 - 13	12.04 ± 0.14	11.86 ± 0.10	11.61 ± 0.11	11.73 ± 0.10
14 - 18	12.56 ± 0.21	11.98 ± 0.16	12.28 ± 0.18	11.80 ± 0.07
	20. Lower Face Height (cm)			
8 - 11	6.79 ± 0.09	6.55 ± 0.09	6.25 ± 0.11	6.08 ± 0.07
12 - 13	6.85 ± 0.11	6.85 ± 0.08	6.39 ± 0.08	6.51 ± 0.08
14 - 18	7.35 ± 0.14	6.79 ± 0.16	6.79 ± 0.14	6.59 ± 0.06

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	21. Posterior Face Height (cm)			
8 - 11	7.07 ± 0.12	7.08 ± 0.07	6.99 ± 0.11	6.79 ± 0.09
12 - 13	7.43 ± 0.08	7.49 ± 0.10	7.30 ± 0.11	7.35 ± 0.09
14 - 18	8.04 ± 0.12	7.47 ± 0.16	7.89 ± 0.16	7.48 ± 0.09
	22. Posterior Upper Face Height (cm)			
8 - 11	2.58 ± 0.06	2.55 ± 0.04	2.47 ± 0.05	2.35 ± 0.04
12 - 13	2.71 ± 0.05	2.64 ± 0.06	2.71 ± 0/05	2.58 ± 0.05
14 - 18	3.02 ± 0.10	2.65 ± 0.05	2.61 ± 0.06	2.42 ± 0.06
	23. Posterior Lower Face Height (cm)			
8 - 11	4.48 ± 0.07	4.53 ± 0.06	4.52 ± 0.08	4.44 ± 0.07
12 - 13	4.72 ± 0.06	4.85 ± 0.06	4.59 ± 0.09	4.77 ± 0.07
14 - 18	5.01 ± 0.08	4.82 ± 0.13	5.28 ± 0.12	5.05 ± 0.06
	24. Overjet (cm)			
8 - 11	0.34 ± 0.04	0.28 ± 0.02	-0.01 ± 0.06	-0.16 ± 0.06
12 - 13	0.27 ± 0.05	0.28 ± 0.07	-0.08 ± 0.08	-0.03 ± 0.05
14 - 18	0.32 ± 0.04	0.20 ± 0.05	0.04 ± 0.06	0.19 ± 0.06

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	25. Overbite (cm)			
8 - 11	0.28 ± 0.03	0.23 ± 0.03	-0.08 ± 0.06	-0.11 ± 0.05
12 - 13	0.21 ± 0.03	0.19 ± 0.03	-0.11 ± 0.07	-0.07 ± 0.05
14 - 18	0.23 ± 0.03	0.22 ± 0.05	0.04 ± 0.07	0.12 ± 0.06
	26. Ramus Length (cm)			
8 - 11	3.81 ± 0.08	3.87 ± 0.06	4.00 ± 0.07	3.87 ± 0.08
12 - 13	4.01 ± 0.06	4.17 ± 0.07	4.00 ± 0.10	4.26 ± 0.07
14 - 18	4.19 ± 0.08	4.20 ± 0.13	4.61 ± 0.13	4.49 ± 0.06
	27. Upper Incisor - A-P Plane (cm)			
8 - 11	0.62 ± 0.04	0.60 ± 0.04	0.32 ± 0.05	0.23 ± 0.04
12 - 13	0.56 ± 0.04	0.57 ± 0.05	0.34 ± 0.06	0.37 ± 0.04
14 - 18	0.71 ± 0.03	0.49 ± 0.05	0.26 ± 0.05	0.46 ± 0.05
	28. Lower Incisor - A-P Plane (cm)			
8 - 11	0.23 ± 0.04	0.26 ± 0.04	0.34 ± 0.06	0.40 ± 0.05
12 - 13	0.27 ± 0.04	0.26 ± 0.06	0.42 ± 0.06	0.42 ± 0.05
14 - 18	0.34 ± 0.05	0.25 ± 0.07	0.23 ± 0.06	0.25 ± 0.06

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	29. Maxillary Dental Arch Length (cm)			
8 - 11	3.85 ± 0.05	3.78 ± 0.05	3.60 ± 0.06	3.42 ± 0.04
12 - 13	3.80 ± 0.05	3.76 ± 0.05	3.42 ± 0.05	3.45 ± 0.05
14 - 18	3.82 ± 0.-6	3.59 ± 0.06	3.48 ± 0.06	3.45 ± 0.05
	30. Mandibular Dental Arch Length (cm)			
8 - 11	3.20 ± 0.05	3.21 ± 0.05	3.48 ± 0.06	3.47 ± 0.07
12 - 13	3.19 ± 0.05	3.22 ± 0.05	3.36 ± 0.07	3.26 ± 0.08
14 - 18	3.13 ± 0.07	3.09 ± 0.06	3.24 ± 0.07	3.14 ± 0.06
	31. Maxillary Molar - Palatal Plane (cm)			
8 - 11	1.79 ± 0.05	1.71 ± 0.03	1.61 ± 0.05	1.54 ± 0.04
12 - 13	1.84 ± 0.03	1.88 ± 0.04	1.80 ± 0.04	1.87 ± 0.04
14 - 18	2.03 ± 0.07	1.91 ± 0.05	1.94 ± 0.05	1.95 ± 0.04
	32. Maxillary Incisor - Palatal Plane (cm)			
8 - 11	2.72 ± 0.05	2.60 ± 0.04	2.35 ± 0.06	2.25 ± 0.05
12 - 13	2.69 ± 0.05	2.72 ± 0.05	2.35 ± 0.05	2.40 ± 0.05
14 - 18	2.90 ± 0.06	2.63 ± 0.09	2.50 ± 0.06	2.55 ± 0.05

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	33. Mandibular Molar - Mandibular Plane (cm)			
8 - 11	2.67 ± 0.07	2.69 ± 0.05	2.52 ± 0.05	1.50 ± 0.04
12 - 13	2.78 ± 0.06	2.78 ± 0.06	2.60 ± 0.06	1.68 ± 0.04
14 - 18	3.04 ± 0.07	2.88 ± 0.08	2.91 ± 0.06	2.72 ± 0.04
	34. Mandibular Incisor - Mandibular Plane (cm)			
8 - 11	3.87 ± 0.05	3.76 ± 0.05	3.45 ± 0.06	3.37 ± 0.05
12 - 13	3.92 ± 0.06	3.87 ± 0.04	3.55 ± 0.05	3.59 ± 0.04
14 - 18	4.19 ± 0.07	3.93 ± 0.07	3.85 ± 0.06	3.72 ± 0.03
	35. Lower Lip - "E" Line (cm)			
8 - 11	-0.09 ± 0.09	-0.05 ± 0.05	-0.09 ± 0.05	0.03 ± 0.05
12 - 13	-0.07 ± 0.05	0.02 ± 0.04	0.10 ± 0.04	0.18 ± 0.03
14 - 18	-0.14 ± 0.06	0.13 ± 0.07	0.18 ± 0.05	0.18 ± 0.05
	36. Upper Lip - "E" Line (cm)			
8 - 11	0.02 ± 0.09	0.02 ± 0.05	0.02 ± 0.05	0.11 ± 0.05
12 - 13	0.04 ± 0.06	0.08 ± 0.04	0.23 ± 0.04	0.31 ± 0.03
14 - 18	0.04 ± 0.06	0.22 ± 0.06	0.25 ± 0.06	0.34 ± 0.04

Means and Standard Errors for All Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	37. Upper Incisor - NA Plane (cm)			
8 - 11	0.26 ± 0.04	0.18 ± 0.04	0.15 ± 0.04	0.02 ± 0.04
12 - 13	0.26 ± 0.04	0.23 ± 0.06	0.17 ± 0.05	0.21 ± 0.04
14 - 18	0.29 ± 0.06	0.18 ± 0.07	0.12 ± 0.06	0.28 ± 0.07
	38. Lower Incisor - NB Plane (cm)			
8 - 11	0.55 ± 0.04	0.60 ± 0.03	0.53 ± 0.05	0.63 ± 0.05
12 - 13	0.56 ± 0.03	0.58 ± 0.05	0.67 ± 0.05	0.63 ± 0.05
14 - 18	0.66 ± 0.04	0.57 ± 0.08	0.51 ± 0.06	0.55 ± 0.06
	39. Pogonion to NB Line (cm)			
8 - 11	0.06 ± 0.03	0.04 ± 0.02	0.07 ± 0.04	0.09 ± 0.02
12 - 13	0.08 ± 0.02	0.08 ± 0.03	0.17 ± 0.03	0.10 ± 0.02
14 - 18	0.03 ± 0.03	0.11 ± 0.04	0.22 ± 0.04	0.21 ± 0.03
	40. Mandibular Length - Wylie (cm)			
8 - 11	10.74 ± 0.09	10.42 ± 0.08	10.08 ± 0.18	9.82 ± 0.26
12 - 13	11.14 ± 0.09	11.04 ± 0.09	11.01 ± 0.18	10.74 ± 0.13
14 - 18	11.51 ± 0.22	11.04 ± 0.23	11.48 ± 0.22	10.88 ± 0.10

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	41. 2 - 28 (cm)			
8 - 11	1.71 ± 0.07	1.65 ± 0.04	1.46 ± 0.09	1.65 ± 0.06
12 - 13	1.81 ± 0.04	1.75 ± 0.04	1.77 ± 0.08	1.79 ± 0.07
14 - 18	2.00 ± 0.07	1.78 ± .08	1.83 ± 0.08	1.74 ± 0.07
	42. 2 - 26 (cm)			
8 - 11	1.99 ± 0.05	1.94 ± 0.03	1.98 ± 0.03	1.91 ± 0.05
12 - 13	1.96 ± 0.05	1.91 ± 0.04	2.01 ± 0.04	1.91 ± 0.03
14 - 18	1.93 ± 0.05	1.95 ± 0.11	2.07 ± 0.05	1.94 ± 0.06
	43. 26 - 24 (cm)			
8 - 11	5.33 ± 0.05	5.28 ± 0.04	5.29 ± 0.05	5.01 ± 0.05
12 - 13	5.41 ± 0.05	5.36 ± 0.09	5.43 ± 0.06	5.47 ± 0.05
14 - 18	5.71 ± 0.09	5.45 ± 0.05	5.69 ± 0.07	5.56 ± 0.07
	44. 26 - 30 (cm)			
8 - 11	1.11 ± 0.09	1.08 ± 0.05	1.17 ± 0.05	0.89 ± 0.06
12 - 13	1.32 ± 0.06	1.23 ± 0.82	1.51 ± 0.06	1.45 ± 0.05
14 - 18	1.50 ± 0.06	1.47 ± 0.11	1.57 ± 0.12	1.67 ± 0.08

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	45. Facial Angle (Degrees)			
8 - 11	83.07 ± 0.90	83.67 ± 0.70	86.34 ± 0.80	82.84 ± 0.78
12 - 13	85.31 ± 0.69	84.47 ± 0.97	86.26 ± 0.49	86.15 ± 0.57
14 - 18	83.56 ± 0.70	84.86 ± 1.35	85.63 ± 1.08	86.33 ± 0.79
	46. Angle of Convexity (Degrees)			
8 - 11	10.01 ± 0.97	11.69 ± 0.82	4.92 ± 0.95	6.64 ± 1.02
12 - 13	8.26 ± 1.07	9.35 ± 1.17	4.78 ± 0.86	4.88 ± 0.63
14 - 18	10.59 ± 1.10	8.46 ± 1.90	4.60 ± 1.29	5.15 ± 1.17
	47. SNA (Degrees)			
8 - 11	82.16 ± 0.74	83.95 ± 0.62	81.31 ± 0.76	80.88 ± 0.59
12 - 13	83.61 ± 0.64	85.57 ± 0.80	82.24 ± 0.61	81.47 ± 0.70
14 - 18	86.32 ± 0.77	83.67 ± 0.64	81.88 ± 0.58	81.66 ± 0.83
	48. SNB (Degrees)			
8 - 11	77.01 ± 0.59	78.17 ± 0.62	78.43 ± 0.69	77.16 ± 0.58
12 - 13	79.18 ± 0.60	80.61 ± 0.67	78.93 ± 0.56	78.52 ± 0.66
14 - 18	80.99 ± 0.73	79.09 ± 0.96	78.55 ± 0.60	77.97 ± 0.79

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	49. ANB (Degrees)			
8 - 11	5.15 ± 0.37	5.77 ± 0.37	2.87 ± 0.33	3.72 ± 0.43
12 - 13	4.43 ± 0.48	4.95 ± 0.61	3.30 ± 0.29	1.94 ± 0.24
14 - 18	5.33 ± 0.52	4.58 ± 0.85	3.32 ± 0.51	3.69 ± 0.51
	50. Mandibular Plane Angle - Frankfort Horizontal (Degrees)			
8 - 11	32.57 ± 0.97	30.67 ± 0.87	25.88 ± 1.04	27.85 ± 0.84
12 - 13	31.08 ± 0.96	31.53 ± 1.27	27.23 ± 1.05	26.06 ± 0.86
14 - 18	32.71 ± 1.32	29.97 ± 1.45	26.74 ± 1.63	25.66 ± 1.11
	51. Interincisal Angle (Degrees)			
8 - 11	128.14 ± 1.71	126.47 ± 1.61	125.56 ± 2.00	122.40 ± 1.76
12 - 13	126.65 ± 1.61	126.68 ± 2.23	122.38 ± 1.79	124.31 ± 2.02
14 - 18	125.29 ± 1.56	129.06 ± 1.88	130.48 ± 2.38	126.91 ± 2.88
	52. Upper Incisor to SN (Degrees)			
8 - 11	103.19 ± 1.13	103.10 ± 1.33	101.60 ± 1.26	99.53 ± 1.08
12 - 13	105.47 ± 1.18	105.15 ± 1.47	101.76 ± 1.58	100.76 ± 1.39
14 - 18	106.53 ± 1.68	100.90 ± 1.98	99.26 ± 1.50	100.91 ± 1.95

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	53. Lower Incisor to Mandibular Plane (Degrees)			
8 - 11	90.37 ± 1.25	94.47 ± 0.87	99.20 ± 1.67	105.07 ± 1.82
12 - 13	91.78 ± 1.17	93.27 ± 1.71	102.77 ± 2.06	102.14 ± 1.93
14 - 18	93.05 ± 1.57	94.90 ± 1.52	97.62 ± 2.16	99.34 ± 1.81
	54. Cranial Base Angle (Degrees)			
8 - 11	132.21 ± 1.20	131.60 ± 0.68	132.44 ± 0.91	133.33 ± 0.80
12 - 13	131.16 ± 0.85	131.53 ± 1.43	129.88 ± 1.15	131.34 ± 0.90
14 - 18	127.72 ± 1.63	130.90 ± 1.06	133.08 ± 0.93	134.49 ± 1.23
	55. 5 - 4 - 17 (Degrees)			
8 - 11	32.08 ± 0.89	32.14 ± 0.67	29.97 ± 0.88	31.67 ± 1.00
12 - 13	30.87 ± 0.78	35.45 ± 1.09	33.72 ± 0.95	32.06 ± 0.86
14 - 18	35.81 ± 0.98	34.19 ± 1.93	34.55 ± 1.11	35.97 ± 1.30
	56. 5 - 4 - 2 (Degrees)			
8 - 11	109.43 ± 1.14	110.58 ± 0.95	108.87 ± 1.19	109.40 ± 1.13
12 - 13	110.56 ± 1.01	116.52 ± 1.23	113.63 ± 1.08	111.29 ± 1.14
14 - 18	116.97 ± 1.21	113.90 ± 2.09	114.31 ± 1.34	115.15 ± 1.45

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	57. Mandibular Plane Angle - SN (Degrees)			
8 - 11	38.30 ± 0.83	35.93 ± 0.78	33.32 ± 1.03	32.97 ± 0.82
12 - 13	36.70 ± 0.84	34.89 ± 1.02	33.59 ± 1.01	33.09 ± 0.99
14 - 18	35.11 ± 1.47	35.12 ± 1.07	32.62 ± 1.38	32.81 ± 1.17
	58. Palatal Plane Angle - SN (Degrees)			
8 - 11	7.00 ± 0.70	6.75 ± 0.58	7.40 ± 0.67	7.19 ± 0.56
12 - 13	6.68 ± 0.67	5.63 ± 0.77	7.48 ± 0.61	7.62 ± 0.65
14 - 18	3.88 ± 0.90	8.16 ± 1.03	9.47 ± 1.00	8.59 ± 0.63
	59. Gonial Angle (Degrees)			
8 - 11	131.55 ± 1.55	127.67 ± 1.01	126.98 ± 1.38	117.65 ± 6.08
12 - 13	130.12 ± 1.14	127/19 ± 1.74	128.26 ± 1.32	125.31 ± 1.31
14 - 18	130.06 ± 1.91	126.59 ± 1.76	126.14 ± 1.70	124.00 ± 1.75
	60. 2 - 4 - 17 (Degrees)			
8 - 11	77.35 ± 0.60	78.41 ± 0.62	78.89 ± 0.69	77.72 ± 0.62
12 - 13	79.69 ± 0.58	81.11 ± 0.67	79.91 ± 0.53	79.12 ± 0.63
14 - 18	81.16 ± 0.72	79.71 ± 1.07	79.75 ± 0.64	79.18 ± 0.83

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	61. Y-Axis Angle (Degrees)			
8 - 11	62.21 ± 1.06	62.34 ± 0.73	58.25 ± 1.03	63.90 ± 1.18
12 - 13	61.47 ± 0.74	63.15 ± 1.03	59.66 ± 0.63	60.46 ± 0.93
14 - 18	63.94 ± 0.71	61.57 ± 1.46	59.50 ± 1.27	60.16 ± 1.04
	62. A - B - Plane Angle (Degrees)			
8 - 11	7.48 ± 0.53	8.41 ± 0.61	4.77 ± 0.52	6.34 ± 0.66
12 - 13	6.83 ± 0.72	7.56 ± 1.03	5.99 ± 0.35	5.12 ± 0.37
14 - 18	7.36 ± 0.75	7.42 ± 1.23	6.53 ± 0.84	6.88 ± 0.78
	63. Overall Soft Tissue Contour (Degrees)			
8 - 11	138.04 ± 0.98	136.90 ± 0.86	134.46 ± 1.77	131.54 ± 1.00
12 - 13	140.63 ± 0.74	136.87 ± 1.03	130.25 ± 0.77	130.56 ± 0.76
14 - 18	136.89 ± 0.99	138.72 ± 1.15	128.89 ± 0.93	131.48 ± 1.49
	64. Soft Tissue Angle of Convexity (Degrees)			
8 - 11	166.40 ± 1.09	164.53 ± 1.07	162.68 ± 0.91	161.42 ± 1.25
12 - 13	166.36 ± 1.09	166.53 ± 1.35	163.14 ± 0.76	164.31 ± 0.61
14 - 18	163.99 ± 1.27	169.72 ± 1.16	161.62 ± 1.55	165.07 ± 1.45

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
65. 6 - SN Plane (Degrees)				
8 - 11	50.68 ± 0.78	52.43 ± 0.81	55.02 ± 1.05	56.30 ± 0.86
12 - 13	53.58 ± 0.70	55.39 ± 1.12	55.64 ± 0.88	57.83 ± 0.69
14 - 18	53.40 ± 1.01	51.55 ± 1.65	56.00 ± 0.83	56.08 ± 0.66
66. FMIA (Degrees)				
8 - 11	57.05 ± 1.16	54.84 ± 1.19	54.80 ± 1.99	47.03 ± 1.63
12 - 13	57.13 ± 1.12	55.19 ± 1.66	49.99 ± 1.84	51.78 ± 1.66
14 - 18	54.22 ± 1.37	55.11 ± 2.29	55.63 ± 2.63	58.98 ± 2.03
67. UI NA (Degrees)				
8 - 11	21.01 ± 1.26	19.15 ± 1.21	20.06 ± 1.15	18.65 ± 0.98
12 - 13	21.14 ± 1.20	19.57 ± 1.84	19.01 ± 1.53	18.96 ± 1.38
14 - 18	20.21 ± 1.58	17.23 ± 2.16	17.38 ± 1.51	19.25 ± 1.95
68. LI to NB (Degrees)				
8 - 11	25.68 ± 1.09	28.59 ± 0.85	31.27 ± 1.80	35.24 ± 1.54
12 - 13	27.67 ± 0.83	18.78 ± 1.33	35.30 ± 1.79	33.76 ± 1.75
14 - 18	29.16 ± 0.85	29.11 ± 1.50	28.08 ± 2.10	30.13 ± 1.84

Means and Standard Errors for all Angular and Linear Measurements Studied, by Group, Sex and Age (Continued)

	Indian		Control	
Age Group	Male	Female	Male	Female
	69. Palatal Plane to Mandibular Plane (Degrees)			
8 - 11	31.29 ± 1.08	29.18 ± 0.80	29.52 ± 1.10	25.77 ± 0.84
12 - 13	30.01 ± 0.98	29.26 ± 0.97	26.10 ± 0.96	25.46 ± 1.06
14 - 18	31.23 ± 1.30	26.95 ± 1.53	23.15 ± 1.13	24.22 ± 0.93
	70. Occlusal Plane to Palatal Plane (Degrees)			
8 - 11	21.98 ± 1.17	19.61 ± 0.69	15.44 ± 0.83	14.69 ± 0.87
12 - 13	21.27 ± 0.75	20.12 ± 0.95	16.87 ± 1.08	16.51 ± 0.86
14 - 18	21.99 ± 1.13	19.90 ± 1.02	17.28 ± 1.22	18.47 ± 0.80
	71. Occlusal Plane to Frankfort Horizontal (Degrees)			
8 - 11	10.59 ± 1.26	11.11 ± 0.80	10.66 ± 0.99	13.15 ± 0.88
12 - 13	9.80 ± 0.85	11.45 ± 1.39	10.80 ± 1.05	9.55 ± 0.76
14 - 18	10.91 ± 1.14	10.07 ± 1.44	9.01 ± 1.08	7.16 ± 1.12
	72. Lower Incisor to Occlusal Plane (Degrees)			
8 - 11	112.35 ± 1.27	114.13 ± 0.96	114.66 ± 1.57	119.78 ± 1.51
12 - 13	113.30 ± 0.86	113.35 ± 1.54	119.04 ± 1.45	118.65 ± 1.56
14 - 18	115.00 ± 1.14	114.81 ± 1.94	114.33 ± 2.06	117.95 ± 1.77

Appendix V

Table XII

Means and Standard Errors of all Angular and Linear Variables for the Main Effect of Group.

Variable	(cm)	Total Sample	Groups: Indian	Control
1.	Max. Pal. Plane	4.81 ± 0.02	4.91 ± 0.02	4.73 ± 0.03
2.	Nasal Bone	2.23 ± 0.02	2.34 ± 0.03	2.14 ± 0.02
3.	Mand. Length (27 - 17)	9.76 ± 0.04	9.72 ± 0.05	9.78 ± 0.06
4.	Post Cranial Base	4.25 ± 0.02	4.37 ± 0.03	4.17 ± 0.02
5.	Corpus Length	7.66 ± 0.03	7.70 ± 0.04	7.64 ± 0.05
6.	Mand. Length (28 - 16)	10.57 ± 0.05	10.63 ± 0.06	10.49 ± 0.09
7.	8 - Facial Plane	2.86 ± 0.02	2.82 ± 0.03	2.89 ± 0.03
8.	10 - Facial Plane	1.99 ± 0.02	2.10 ± 0.03	1.91 ± 0.02
9.	12 - Facial Plane	1.75 ± 0.02	1.84 ± 0.03	1.68 ± 0.02
10.	14 - Facial Plane	1.15 ± 0.02	1.21 ± 0.02	1.11 ± 0.01
11.	Pog. to Mand. Pl.	0.83 ± 0.01	0.98 ± 0.02	0.93 ± 0.01
12.	UI to Facial Pl.	0.62 ± 0.02	0.85 ± 0.03	0.47 ± 0.02
13.	LI to Facial Pl.	0.51 ± 0.02	0.54 ± 0.02	0.48 ± 0.03
14.	Ant. Cranial Base	6.56 ± 0.02	6.53 ± 0.02	6.58 ± 0.02
15.	Glab. to Y-Plane	7.07 ± 0.02	7.08 ± 0.03	7.06 ± 0.03
16.	S - SN Plane	2.05 ± 0.02	2.15 ± 0.02	1.97 ± 0.02
17.	Glab. to SN Plane	1.27 ± 0.03	1.55 ± 0.03	1.07 ± 0.03
18.	Upper Face Height	5.07 ± 0.02	5.03 ± 0.03	5.10 ± 0.03
19.	Total Face Height	11.66 ± 0.05	11.85 ± 0.07	11.53 ± 0.06
20.	Lower Face Height	6.58 ± 0.03	6.82 ± 0.05	6.42 ± 0.04
21.	Post. Face Height	7.32 ± 0.03	7.37 ± 0.05	7.28 ± 0.05
22.	Post. U.F.H.	2.58 ± 0.02	2.67 ± 0.03	2.51 ± 0.03
23.	Post. L.F.H.	4.73 ± 0.03	4.70 ± 0.03	4.76 ± 0.04
24.	Overjet	0.11 ± 0.02	0.28 ± 0.02	-0.01 ± 0.03
25.	Overbite	0.07 ± 0.01	0.22 ± 0.01	-0.04 ± 0.03
26.	Ramus Length	4.12 ± 0.03	4.01 ± 0.03	4.20 ± 0.04
27.	UI to AP	0.44 ± 0.02	0.59 ± 0.02	0.33 ± 0.02
28.	LI to AP	0.32 ± 0.02	0.27 ± 0.02	0.35 ± 0.02
29.	Max. Dental Arch	3.60 ± 0.02	3.78 ± 0.02	3.47 ± 0.02
30.	Mand. Dental Arch	3.27 ± 0.02	3.18 ± 0.02	3.33 ± 0.03
31.	U6 to Pal. Plane	1.80 ± 0.01	1.83 ± 0.02	1.78 ± 0.02
32.	UI to Pal. Plane	2.52 ± 0.02	2.70 ± 0.02	2.40 ± 0.03
33.	L6 to Mand. Plane	2.70 ± 0.02	2.78 ± 0.03	2.65 ± 0.02
34.	LI to Mand. Plane	3.71 ± 0.02	3.89 ± 0.03	3.58 ± 0.03
35.	L. Lip to "E" Line	0.39 ± 0.02	-0.04 ± 0.03	0.09 ± 0.02

Table XII (Continued)

Variable	Total Sample	Groups Indian	Control
36. U. Lip to "E" Line	0.14 ± 0.02	0.04 ± 0.03	0.21 ± 0.02
37. UI to NA	0.19 ± 0.02	0.23 ± 0.02	0.16 ± 0.02
38. LI to NB	0.59 ± 0.016	0.59 ± 0.01	0.59 ± 0.02
39. Pogonion to NB	0.11 ± 0.01	0.06 ± 0.01	0.14 ± 0.01
40. Mand. Length	10.84 ± 0.05	10.92 ± 0.06	10.73 ± 0.09
41. 2 - 28	1.74 ± 0.02	1.77 ± 0.03	1.71 ± 0.04
42. 2 - 26	1.96 ± 0.12	1.95 ± 0.02	1.96 ± 0.02
43. 26 - 24	5.39 ± 0.02	5.40 ± 0.03	5.39 ± 0.03
44. 26 - 30	1.31 ± 0.03	1.25 ± 0.03	1.35 ± 0.33
45. Facial Angle	84.96 ± 0.24	84.16 ± 0.34	85.52 ± 0.32
46. Angle of Convexity	7.14 ± 0.33	9.91 ± 0.45	5.21 ± 0.40
47. SNA	82.6 ± 0.22	84.13 ± 0.31	81.53 ± 0.28
48. SNB	78.56 ± 0.20	79.03 ± 0.30	78.22 ± 0.27
49. ANB	4.04 ± 0.13	5.09 ± 0.20	3.31 ± 0.16
50. Mand. Plane (FH)	28.54 ± 0.34	31.37 ± 0.44	26.57 ± 0.44
51. UI to LI	125.90 ± 0.61	126.87 ± 0.74	125.20 ± 0.91
52. UI to SN	102.08 ± 0.44	104.17 ± 0.59	100.59 ± 0.60
53. LI to MP	97.75 ± 0.57	92.94 ± 0.53	101.19 ± 0.80
54. Cranial Base Angle	131.88 ± 0.31	131.04 ± 0.45	132.48 ± 0.42
55. 5 - 4 - 17	32.94 ± 0.31	33.00 ± 0.41	32.90 ± 0.44
56. 5 - 4 - 2	112.14 ± 0.38	112.41 ± 0.54	111.95 ± 0.53
57. Mand. Plane (SN)	34.32 ± 0.32	36.12 ± 0.40	33.06 ± 0.43
58. Pal. Plane (SN)	7.27 ± 0.21	6.37 ± 0.32	7.91 ± 0.28
59. Gonial Angle	123.39 ± 1.50	127.07 ± 1.68	125.00 ± 1.25
60. 2 - 4 - 17	79.18 ± 0.20	79.41 ± 0.30	79.03 ± 0.28
61. Y - Axis	61.47 ± 0.30	62.38 ± 0.37	60.10 ± 0.48
62. A - B Plane	6.60 ± 0.20	7.57 ± 0.32	5.91 ± 0.25
63. 7 - 8 - 14	133.92 ± 0.40	138.06 ± 0.41	131.28 ± 0.49
64. 4 - 23 - 17	164.23 ± 0.35	165.09 ± 0.51	163.09 ± 0.47
65. 6 - SN Plane	54.87 ± 0.28	52.93 ± 0.40	56.23 ± 0.34
66. FMIA	53.66 ± 0.54	55.67 ± 0.57	52.21 ± 0.82
67. UINA	19.31 ± 0.42	19.91 ± 0.60	18.89 ± 0.59
68. LI to NB	30.69 ± 0.49	28.10 ± 0.43	32.54 ± 0.75
69. Pal. Plane to M.P.	27.05 ± 0.33	29.75 ± 0.44	25.15 ± 0.42
70. Occ. Pl. to Pal. Pl.	-18.20 ± 0.31	20.72 ± 0.38	16.46 ± 0.39
71. Occ. Pl. to F.H.	-10.36 ± 0.30	10.69 ± 0.44	10.13 ± 0.42
72. LI to Occ. Pl.	-115.99 ± 0.46	113.72 ± 0.49	117.58 ± 0.69

Table XIII

Means and Standard Errors of all Angular and Linear Variables for the Main Effect of Sex.

Variable	(cm)	Sex: Male	Female
1.	Max. Pal. Plane	4.87 ± 0.03	4.76 ± 0.02
2.	Nasal Bone	2.23 ± 0.02	2.22 ± 0.02
3.	Mand. Length (27 - 17)	9.91 ± 0.06	9.63 ± 0.05
4.	Post Cranial Base	4.33 ± 0.03	4.18 ± 0.02
5.	Corpus Length	7.76 ± 0.05	7.58 ± 0.04
6.	Mand. Length (28 - 16)	10.68 ± 0.08	10.47 ± 0.06
7.	8 - Facial Plane	2.88 ± 0.03	2.85 ± 0.02
8.	10 - Facial Plane	2.04 ± 0.02	1.94 ± 0.02
9.	12 - Facial Plane	1.81 ± 0.03	1.69 ± 0.02
10.	14 - Facial Plane	1.17 ± 0.02	1.14 ± 0.01
11.	Pog. to Mand. Pl.	0.86 ± 0.02	0.81 ± 0.01
12.	UI to Facial Pl.	0.62 ± 0.03	0.62 ± 0.02
13.	LI to Facial Pl.	0.49 ± 0.02	0.52 ± 0.02
14.	Ant. Cranial Base	6.66 ± 0.03	6.47 ± 0.02
15.	Glab. to Y-Plane	7.17 ± 0.03	6.98 ± 0.02
16.	S - SN Plane	2.05 ± 0.03	1.28 ± 0.03
17.	Glab. to SN Plane	1.25 ± 0.04	2.04 ± 0.02
18.	Upper Face Height	5.15 ± 0.04	5.01 ± 0.02
19.	Total Face Height	11.83 ± 0.08	11.52 ± 0.05
20.	Lower Face Height	6.68 ± 0.06	6.50 ± 0.04
21.	Post. Face Height	7.42 ± 0.06	7.23 ± 0.04
22.	Post. U.F.H.	2.66 ± 0.03	2.51 ± 0.02
23.	Post. L.F.H.	4.75 ± 0.04	4.72 ± 0.03
24.	Overjet	0.12 ± 0.03	0.09 ± 0.02
25.	Overbite	0.07 ± 0.03	0.06 ± 0.02
26.	Ramus Length	4.11 ± 0.04	4.13 ± 0.03
27.	UI to AP	0.44 ± 0.02	0.43 ± 0.02
28.	LI to AP	0.30 ± 0.02	0.32 ± 0.02
29.	Max. Dental Arch	3.64 ± 0.03	3.56 ± 0.02
30.	Mand. Dental Arch	3.28 ± 0.03	3.26 ± 0.03
31.	U6 to Pal. Plane	1.82 ± 0.02	1.78 ± 0.02
32.	UI to Pal. Plane	2.55 ± 0.03	2.49 ± 0.02
33.	L6 to Mand. Plane	2.73 ± 0.03	2.68 ± 0.02
34.	LI to Mand. Plane	3.77 ± 0.03	3.66 ± 0.02
35.	L. Lip to "E" Line	0.01 ± 0.02	0.08 ± 0.02
36.	U. Lip to "E" Line	0.10 ± 0.02	0.18 ± 0.02
37.	UI to NA	0.20 ± 0.02	0.18 ± 0.02

Table XIII (Continued)

Variable	Sex: Male	Sex: Female
38. LI to NB	0.57 ± 0.02	0.60 ± 0.02
39. Pogonion to NB	0.11 ± 0.02	0.10 ± 0.01
40. Mand. Length	11.01 ± 0.08	10.68 ± 0.06
41. 2 - 28	1.77 ± 0.03	1.72 ± 0.02
42. 2 - 26	1.99 ± 0.02	1.92 ± 0.02
43. 26 - 24	5.46 ± 0.02	5.34 ± 0.03
44. 26 - 30	1.36 ± 0.04	1.27 ± 0.03
45. Facial Angle	85.26 ± 0.34	84.70 ± 0.34
46. Angle of Convexity	6.79 ± 0.47	7.45 ± 0.46
47. SNA	82.69 ± 0.30	82.52 ± 0.32
48. SNB	78.79 ± 0.27	78.36 ± 0.29
49. ANB	3.90 ± 0.19	4.16 ± 0.20
50. Mand. Plane (FH)	28.93 ± 0.54	28.21 ± 0.44
51. UI to LI	126.42 ± 0.81	125.47 ± 0.90
52. UI to SN	102.73 ± 0.60	101.55 ± 0.63
53. LI to MP	96.21 ± 0.80	99.06 ± 0.79
54. Cranial Base Angle	131.30 ± 0.45	132.37 ± 0.42
55. 5 - 4 - 17	32.56 ± 0.42	33.27 ± 0.45
56. 5 - 4 - 2	111.99 ± 0.54	112.26 ± 0.55
57. Mand. Plane (SN)	34.76 ± 0.48	33.94 ± 0.41
58. Pal. Plane (SN)	7.21 ± 0.34	7.33 ± 0.27
59. Gonial Angle	126.61 ± 1.54	124.64 ± 1.43
60. 2 - 4 - 17	79.43 ± 0.27	78.98 ± 0.30
61. Y - Axis	61.06 ± 0.43	61.85 ± 0.42
62. A - B Plane	6.35 ± 0.27	6.81 ± 0.29
63. 7 - 8 - 14	134.52 ± 0.63	133.41 ± 0.51
64. 4 - 23 - 17	163.93 ± 0.48	164.49 ± 0.51
65. 6 - SN Plane	54.27 ± 0.39	55.39 ± 0.39
66. FMIA	54.77 ± 0.79	52.70 ± 0.74
67. UINA	19.76 ± 0.57	18.94 ± 0.61
68. LI to NB	29.85 ± 0.70	31.40 ± 0.68
69. Pal. Plane to M.P.	27.55 ± 0.51	26.61 ± 0.43
70. Occ. Pl. to Pal. Pl.	18.74 ± 0.48	17.74 ± 0.39
71. Occ. Pl. to F.H.	10.24 ± 0.43	10.46 ± 0.43
72. LI to Occ. Pl.	114.85 ± 0.64	116.95 ± 0.66

Table XIV

Means and Standard Errors for all Angular and Linear Measurements for the Main Effect of Age.

Variable	Age Groups in Years 8 - 11	12 - 13	14 - 18
1. Max. Pal. Plane	4.70 ± 0.03	4.78 ± 0.03	4.99 ± 0.03
2. Nasal Bone	2.15 ± 0.02	2.28 ± 0.03	2.26 ± 0.03
3. Mand. Length (27 - 17)	9.33 ± 0.05	9.89 ± 0.04	10.19 ± 0.07
4. Post Cranial Base	4.12 ± 0.03	4.35 ± 0.02	4.30 ± 0.04
5. Corpus Length	7.30 ± 0.04	7.79 ± 0.04	7.98 ± 0.05
6. Mand. Length (28 - 16)	10.05 ± 0.07	10.71 ± 0.06	11.00 ± 0.09
7. 8 - Facial Plane	2.69 ± 0.03	2.89 ± 0.02	3.07 ± 0.04
8. 10 - Facial Plane	1.96 ± 0.03	1.98 ± 0.02	2.04 ± 0.04
9. 12 - Facial Plane	1.72 ± 0.03	1.74 ± 0.02	1.79 ± 0.03
10. 14 - Facial Plane	1.07 ± 0.02	1.19 ± 0.02	1.22 ± 0.02
11. Pog. to Mand. Pl.	0.79 ± 0.02	0.83 ± 0.02	0.91 ± 0.02
12. UI to Facial Pl.	0.63 ± 0.03	0.62 ± 0.03	0.62 ± 0.04
13. LI to Facial Pl.	0.53 ± 0.03	0.53 ± 0.03	0.44 ± 0.04
14. Ant. Cranial Base	6.43 ± 0.03	6.55 ± 0.03	6.75 ± 0.04
15. Glab. to Y-Plane	6.95 ± 0.03	7.04 ± 0.03	7.27 ± 0.04
16. S - SN Plane	2.01 ± 0.02	2.09 ± 0.03	2.03 ± 0.04
17. Glab. to SN Plane	1.26 ± 0.04	1.32 ± 0.04	1.21 ± 0.04
18. Upper Face Height	4.83 ± 0.03	5.17 ± 0.03	5.29 ± 0.04
19. Total Face Height	11.21 ± 0.07	11.80 ± 0.06	12.12 ± 0.08
20. Lower Face Height	6.37 ± 0.05	6.63 ± 0.05	6.82 ± 0.06
21. Post. Face Height	6.97 ± 0.05	7.38 ± 0.05	7.71 ± 0.07
22. Post. U.F.H.	2.47 ± 0.02	2.65 ± 0.03	2.62 ± 0.04
23. Post. L.F.H.	4.49 ± 0.03	4.73 ± 0.04	5.08 ± 0.05
24. Overjet	0.08 ± 0.03	0.08 ± 0.03	0.17 ± 0.03
25. Overbite	0.05 ± 0.02	0.04 ± 0.03	0.13 ± 0.03
26. Ramus Length	3.89 ± 0.04	4.12 ± 0.04	4.43 ± 0.05
27. UI to AP	0.42 ± 0.02	0.45 ± 0.02	0.45 ± 0.03
28. LI to AP	0.32 ± 0.02	0.35 ± 0.03	0.26 ± 0.03
29. Max. Dental Arch	3.64 ± 0.03	3.59 ± 0.03	3.55 ± 0.03
30. Mand. Dental Arch	3.35 ± 0.03	3.26 ± 0.03	3.16 ± 0.04
31. U6 to Pal. Plane	1.65 ± 0.02	1.85 ± 0.02	1.95 ± 0.03
32. UI to Pal. Plane	2.45 ± 0.03	2.52 ± 0.03	2.61 ± 0.04
33. L6 to Mand. Plane	2.58 ± 0.03	2.70 ± 0.03	2.86 ± 0.03
34. LI to Mand. Plane	3.58 ± 0.03	3.72 ± 0.03	3.88 ± 0.03
35. L. Lip to "E" Line	-0.04 ± 0.03	0.07 ± 0.02	0.12 ± 0.03
36. U. Lip to "E" Line	0.04 ± 0.03	0.18 ± 0.02	0.23 ± 0.03
37. UI to NA	0.14 ± 0.02	0.22 ± 0.02	0.22 ± 0.03

Table XIV (Continued)

Variable	Age Groups in Years 8 - 11	12 - 13	14 - 18
38. LI to NB	0.58 ± 0.02	0.61 ± 0.02	0.56 ± 0.03
39. Pogonion to NB	0.06 ± 0.01	0.11 ± 0.01	0.16 ± 0.02
40. Mand. Length	10.36 ± 0.74	11.01 ± 0.06	11.20 ± 0.09
41. 2 - 28	1.63 ± 0.03	1.79 ± 0.03	1.83 ± 0.04
42. 2 - 26	1.95 ± 0.02	1.95 ± 0.02	1.98 ± 0.03
43. 26 - 24	5.21 ± 0.02	5.43 ± 0.03	5.61 ± 0.04
44. 26 - 30	1.05 ± 0.03	1.39 ± 0.03	1.57 ± 0.05
45. Facial Angle	83.99 ± 0.41	85.65 ± 0.33	85.39 ± 0.50
46. Angle of Convexity	8.22 ± 0.54	6.53 ± 0.48	6.46 ± 0.71
47. SNA	82.08 ± 0.35	82.93 ± 0.37	82.88 ± 0.43
48. SNB	77.74 ± 0.32	79.16 ± 0.32	78.87 ± 0.40
49. ANB	4.33 ± 0.22	3.76 ± 0.21	4.01 ± 0.29
50. Mand. Plane (FH)	28.94 ± 0.51	28.59 ± 0.55	27.91 ± 0.77
51. UI to LI	125.35 ± 0.91	124.88 ± 0.98	128.00 ± 1.34
52. UI to SN	101.68 ± 0.63	102.99 ± 0.73	101.46 ± 0.97
53. LI to MP	97.98 ± 0.90	98.06 ± 1.03	97.01 ± 1.03
54. Cranial Base Angle	132.42 ± 0.43	131.01 ± 0.52	132.27 ± 0.69
55. 5 - 4 - 17	31.43 ± 0.45	32.75 ± 0.48	35.26 ± 0.66
56. 5 - 4 - 2	109.59 ± 0.55	112.59 ± 0.60	115.06 ± 0.76
57. Mand. Plane (SN)	34.78 ± 0.47	34.44 ± 0.51	33.50 ± 0.68
58. Pal. Plane (SN)	7.09 ± 0.31	6.99 ± 0.34	7.91 ± 0.49
59. Gonial Angle	125.12 ± 1.94	127.55 ± 0.70	125.40 ± 1.70
60. 2 - 4 - 17	78.15 ± 0.32	79.81 ± 0.31	79.80 ± 0.41
61. Y - Axis	61.71 ± 0.52	61.51 ± 0.47	61.16 ± 0.59
62. A - B Plane	6.73 ± 0.33	6.20 ± 0.30	6.94 ± 0.44
63. 7 - 8 - 14	134.72 ± 0.67	134.00 ± 0.62	132.66 ± 0.80
64. 4 - 23 - 17	163.46 ± 0.58	164.93 ± 0.46	164.39 ± 0.82
65. 6 - SN Plane	53.94 ± 0.49	55.80 ± 0.43	54.94 ± 0.49
66. FMIA	52.94 ± 0.86	53.34 ± 0.85	55.06 ± 1.15
67. UINA	19.52 ± 0.57	19.66 ± 0.73	18.58 ± 0.94
68. LI to NB	30.67 ± 0.77	31.67 ± 0.84	29.40 ± 0.96
69. Pal. Plane to M.P.	27.69 ± 0.51	27.45 ± 0.54	25.88 ± 0.67
70. Occ. Pl. to Pal. Pl.	17.49 ± 0.51	18.39 ± 0.50	18.95 ± 0.56
71. Occ. Pl. to F.H.	11.54 ± 0.48	10.24 ± 0.48	8.83 ± 0.61
72. LI to Occ. Pl.	115.61 ± 0.73	116.50 ± 0.77	115.84 ± 0.97

APPENDIX VI

Variables Selected for the Discriminant Function Analysis

Linear Measurements

1. 24-25: Maxillary palatal plane length which includes the length of the maxilla and the palatal bones (Figure 11).

2. 4-5: The length of the nasal bone (Figure 11).

11. 17-Mandibular Plane (32-15): The vertical height of the anterior limit of the mandible (chin point) in relation to the mandibular plane (Figure 11).

12. 20-Facial Plane: The horizontal position of the upper incisors in relation to the anterior facial plane.

16. 5-SN Plane: The vertical distance that the tip of the nasal bone lies below the anterior cranial base (Figure 12).

17. 3-SN Plane: The height of the convexity of the frontal bone in relation to the anterior cranial base (Figure 12).

19. 4-15: The vertical height of the anterior portion of the face in relation to the anterior cranial base and is indicative of total anterior facial development (Figure 12).

20. 24-15: The lower face height measured from the anterior nasal spine to menton (Figure 12).

21. 32-2: The vertical height of the posterior face in relation to the anterior cranial base (Figure 13).

26. 27-Mandibular Plane: The length of the ramus from articular to gonion (Figure 11).

26. 27-Mandibular Plane: The length of the ramus from articular gonion (Figure 11).

27. 20-A-P Plane: The relationship of the maxillary incisor to the skeletal profile.

28. 21-A-P Plane: The relationship of the mandibular incisor to the skeletal profile.

29. 30-20: The length of the maxillary dental arch from the disto-buccal cusp of the 1st molar to the central incisor (Figure 14).

30. 31-21: The length of the mandibular dental arch from the disto-buccal cusp of the lower 1st molar to the lower central incisor (Figure 11).

37. 20-NA Plane: The linear relationship of the maxillary incisor to the line joining nasion and point A. This is a measure of the A-P position of the incisor.

39. P to NB: The effective chin button in relationship to the NB line.

Angular Measurements

45. Facial Angle: An expression of the degree of recession or protrusion of the chin and is used in typing faces as retrognathic, orthognathic prognathic (Angle 1, Figure 17).

46. Angle of Convexity: The anterior limit of the maxilla in the profile with point A as the vertex of an angle formed by the NA line and the AP line. This angle is recorded as a plus if A point is anterior to the facial plane and minus if it is posterior (Angle 2, Figure 16).

47. SNA: The relationship of the maxillary apical base to the anterior cranial base (Angle 3, Figure 16).

48. SNB: The angle relates the mandibular apical base to the anterior cranial base (Angle 4, Figure 17).

49. ANB: Relates the anterior limits of the maxillary and mandibular apical bases to each other (Angle 5).

53. LI to MP: Relates the lower incisor to the mandibular plane (Angle 9, Figure 18).

54. 29-2-4: Relates the anterior and posterior cranial base (Angle 10, Figure 16).

57. Mandibular Plane to SN: Relates the inferior border of the mandible to the anterior cranial base (Angle 13, Figure 17).

58. Palatal Plane to SN: Relates the maxilla to the anterior cranial base. Changes in this angle may reflect differences in the relative vertical development of the anterior and posterior nasal spines (Angle 14, Figure 16).

65. 6-SN Plane (21): Records the relationship of orbitale to SN and is a measure of the degree of retrusion of orbitale (Angle 21, Figure 19).

68. LI to NB: Records the relationship of the mandibular incisor to the line NB and is a measure of the proclination of the mandibular incisors (Angle 24, Figure 16).