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CRANIOFACIAL GROWTH INCREMENTS AFTER HAND-WRIST SKELETAL ADULTHOOD

by

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Abstract

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Prediction and evaluation of the craniofacial maturational status, by the orthodontist is, usually based on chronological age, changes in height, dental age assessment, sexual maturity, skeletal age assessment, or any combination of these.

When assessing craniofacial development with the help of the skeletal age, the most important criteria used are the evaluation of the carpal, metacarpal and phalanges of the hand and wrist. This evaluation includes examination of the number of centers of ossification present, the degree of calcification, and the degree of epiphyseal union.

Only the hand and wrist are recommended (in this study) for skeletal-maturation assessments. The hand has a tested usable relationship to growth in body size and build.

The purpose of this study was to evaluate how reliable is the skeletal age assessment of maturity from the hand-wrist radiograph.

The sample in this study consisted of 21 males and 34 females from the files of Bolton-Brush study at Case Western Reserve University, Cleveland, Ohio.

The population was Caucasian and represented primarily the upper middle-class population of Cleveland. The subjects were all ClI skeletal and dental, not subjected to orthodontic treatment. They were examined every three months for the first postnatal year, after which they were examined every 6 months, from the age of 12 months until the age of 6 years and subsequently they were examined every year.

The assessment of skeletal adulthood was evaluated for each case from the hand-wrist films available in their records. The inspectional method and the Atlas of Pyle-Waterhouse and Greulich (1959) was used for the evaluation.

Also, 21 measurements were assessed from lateral and frontal radiographs for intervals from two years before and after the skeletal adulthood exactly.

Comparisons of growth increments were made for the intervals of two years before the skeletal adulthood was reached to two years after as well as four years later.

By measurement of the means for each time interval, and the differences between them we tried to evaluate the existence of any significant clinical or statistical difference.

In the first repeated measures analysis of variance, which included two years before and two years after adulthood results, that there is a sex difference for 12 out of 21 variables. Also, 15 measurements seemed to change significantly over time for both sexes. From these 15 variables 4 changed significantly in the period included from two years before adulthood to the actual adulthood with no significant change after that. Sex interaction was not found except for 3 variables (Go-Go, Zy-Zy, and NS-GoGn).

In the second repeated measures analysis of variance increments of growth were compared between two years before adulthood to four years after adulthood and the same questions as above tried to be answered. Again sex influence was found in 10 out of 21 variables.

In the over time change analysis only 6 measurements did not seem to change over time. Finally all of the variables except NP-AB and NS-GoGn (mandibular plane angle) showed no time and sex interaction.

Clinically, increments of growth observed 2 and 4 years after the skeletal adulthood was reached, were significantly smaller in comparison with those achieved 2 years before adulthood and do not seem to help measurably the clinician, to achieve his treatment goals, assisted by growth.

DEDICATED

TO

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INTRODUCTION

In the present study an attempt was made to evaluate the validity of the hand-wrist radiograph film in the assessment of the maturational level of the patient.

An effort was made to compare increments of growth (if there is any) before and after the adulthood is reached (assessed from the hand-wrist film), for males and females, who have never received orthodontic treatment. An attempt was also made to find, if there is any similar growth pattern for the two genders, and if there is a sex interaction over this time period.

Growth is an important factor in determining the timing as well as the type of treatment in the use of dentofacial orthopedics versus surgical orthodontics. When growth is present, the clinician can treat the patient having dentofacial deviations with orthodontics and/or orthopedics appliances. When growth is no longer present, surgical orthodontics may be the only effective method of correcting severe associated dental and skeletal deviations.

It is shown that both body and facial growth follow a velocity curve that is rapid in infancy, shows a deceleration in early childhood, continuing with a maximum acceleration during puberty, and finishing with a deceleration as growth is completed (Bambha; 1961-Tanner and Whitehouse, 1962).

It would appear very simple to evaluate remaining growth by simply puting the individual patient in such curves according to chronological age.

Many studies have shown that there is an in individual variability in timing, velocity and duration of growth compared to chronological age. More precise methods of assessment of the maturational status of an individual are thus needed to satisfy the above mentioned events in orthodontics and/or orthopedic treatment planning.

Characteristics of developmental status such as voice changes, secondary sex characteristics, menarche, statural height, and dental and skeletal age have been used to evaluate the biological age (developmental level) Nolla 1961; Tanner and Whitehouse, and 1962; Tanner 1955, 1976.

Skeletal age, the most widely used method is concerned with a sequential study of the bones, of the characteristics of increasing size and maturity between the beginning of ossification and the completion of the epiphyseal fusion. This separation between the diaphysis and the epiphysis decreases at a biologic rate until its complete disappearance. For the study of bone development, many areas of the human skeleton have been used, including the hand, wrist, the vertebral column, the hip, the knee, the foot, the elbow and the shoulder.

In the study of Bagley (1959), it was found that possible prediction of the adult height within reasonable limits could be made if the present skeletal age and standing height of a child are given.

After some years Bambha and Van Natta (1963) found an association between skeletal age maturation and facial growth during adolescence at 2 extremes. First, an early facial growth was observed in individuals who matured early with an advanced skeletal age. Second, children who had a delayed skeletal maturation pattern tended to grow later with regard to the face. Comparisons of chronological and skeletal age were made using Sella-Gnathion, as a plane for measurement.

A reduced variability, concerning the pubertal period of the sample, when chronological and skeletal ages were compared for different physical measurements, was found by Johnston (1962) for patients grouped by skeletal age assessment.

The various ossification events of the hand-wrist area have been studied extensively in recent years, but reliability for assessment of biological age has been controversial.

Smith (1980), in reviewing the literature on growth prediction and the pubertal spurt using the hand-wrist radiograph, found it questionable in providing useful information for female patients in contrast with that

provided for male patients.

The clinical significance of the present study will focus on the reliability of the hand-wrist film in assessing skeletal maturity and, second on the value of utilization by the orthodontist. After the skeletal adulthood is defined with the hand-wrist radiographic film, the present data can help in the selection of the appropriate treatment modality for the individual patient.

LITERATURE REVIEW

To the practicing orthodontist, experience is the knowledge gained in reevaluating cases clinically with respect to accomplishments made throughout the treatment. Unfortunately, in every case of malocclusion, growth and development are not so perceptible as study casts and cephalometric head plates, viewed before and after treatment. Growth and development being a biologic process often are unpredictable but are the most important factors in the correction of the malocclusions.

We must add the variable of early or late maturation in children. The clinical orthodontist must decide as to the type of maturation (normal, early, or late) in which his patient may be classified. He must be constantly watchful of certain influences in order to ascertain the limitations of his treatment.

The diagnosis of an orthodontic case includes the assessment of extent of structure and function, and estimates of the extent to which further natural growth is to be expected. This natural growth may assist manipulative treatment, and its absence may indicate a need for surgical correction. Estimates of facial growth potential, while not precise, are assisted greatly by assessment of skeletal maturity. Determination of chronological age, dental age and skeletal age help the

clinician as useful diagnostic procedures, and to decide which treatment modality should be followed. Usually it is the skeletal age which becomes a highly significant factor in the evaluation of particular types of malocclusion.

Knowing that children grow at varying rates, in general, we can determine or differentiate the moderate maturational schedule from patterns of either extremely rapid or very slow skeletal development.

It, therefore, becomes evident that in correlating individual "biological clocks" to types of malocclusions or assessments of skeletal maturation can be extremely valuable and can affect the choice of treatment. Examples of this significant relationship between skeletal maturation and selection of an orthodontic treatment procedure can be drawn from all the three Angle's classification types of malocclusions. Prediction and evaluation of craniofacial development by the clinician is presently based on chronological age, changes in height, dental age assessment, sexual maturity, skeletal age assessment, or any combination of these.

The assessment of skeletal maturity is basically an accepted technique for determining the maturational status of an individual. Many methods have been suggested for the assessment of skeletal maturity, although the two

most commonly used are the "inspectional" and "bone specific" approaches.

The main purpose of a skeletal age assessment in orthodontic diagnosis seems simple. It is well established that there is a spurt in the growth of facial components during adolescence. Knowing whether or not this period of rapid facial growth has occurred, or how long before it will begin, can be important in some borderline extraction cases, in the timing of headgear therapy, or in the prognosis for skeletal Class III and Class II discrepancies. A problem in predicting the growth spurt, however, is the existence of enormous individual variablity of growth during adolescence.

Since chronological age is such a poor indication of the stage of adolescent development, we seek a more accurate measure - a "biologic age." Short of actual longitudinal data or growth increments in height, the biologic age most closely related to facial growth has been the "skeletal age", and the hand-wrist film is the most standardized and studied method for skeletal age assessment.

An assumption underlying the use of hand-wrist radiographs is that if we now take, for example, 100 children and determine a skeletal age for each one, the variability of these skeletal ages will be less than the variability in chronologic age, and this decrease in

variation will be sufficient to be of clinical (not only statistical) significance.

It appears from many studies, that menarche, skeletal age, and peak of growth in stature are better predictors of the spurt of growth than the chronological age. According to Acheson (1966) the hand, including the wrist, has received a considerable amount of attention in the literature, because of the availability for radiography and its suitability for study due to its wide range of component bones. Many investigators suggest that this region offers a fair index of the maturity of the entire skeleton of the healthy children.

The hand-wrist roentgenogram was the criterion of assessment for skeletal maturation of the cases in the present study. It was felt that a more convenient, rapid and precise method was needed, a method providing more information about the developmental status of the child than could properly be inferred from weight and age alone.

Greulich (1959) has stated that the bones of the hand and wrist, like those of the rest of the body, appear to have a certain individuality. This is seen in the constant order in which the carpals and the epiphyses begin to ossify and in the regular sequence in which the latter fuse with the shafts. These processes occur with great regularity in children who are in good health, and

the order in which they occur is probably determined genetically.

The roentgenograms of the hand and wrist were taken when treatment was started and again when treatment was concluded.

If the orthodontist has to evaluate properly the role he plays in correcting malocclusion, he must have the opportunity to examine the conditions over which he had the least control, and these are "growth and development."

More specifically, he must have a method to accurately determine the time the patient reaches his final skeletal maturation. It is the purpose of this study to examine the hand and wrist method of skeletal assessment as a precise and reliable method to define the adulthood.

Historical Observations on the Maturation of the Skeleton.

Wingate Todd, one of the leading figures in the field of physical development, stated in 1937: "Maturation progress is evident in every part of the skeleton, but it is in the transformation of fibrous tissue and cartilage into bone, that the most easily identifiable criteria present themselves."

Thus, when we say "maturation", we must already differentiate this process from growth, which is the

formation of new tissue and which in many limb bones occurs in the epiphyseal growth cartilage plates. Maturation here is defined as a metamorphosis of the biological and chemical nature of tissue.

In the skeleton of the healthy child the two processes growth (the creation of new cells and tissues) and maturation (subsequent consolidation of the tissues into permanent form), proceed "pari passu", the one with the other.

Before the discovery of x-rays and the evolution of clinical radiology, studies of ossification involving skeletal cartilage were conducted only on cadavers of children, sometimes by microscopy, but usually with the naked eye.

Within ten years of Roentgen's discovery, everyone understood that calcium is radiopaque while cartilage is not, so that the earliest stages of the ossification process are clearly visible on x-rays.

J.W. Pryor (1905) was the first to consider seriously the biologic implications of the changing shadows seen in the x-rays of children's hands. He made three important observations. 1. The bones of the female ossify in advance of those of the male. This is measured at first in days, then months, then years. 2. Regardless of variations (normal) ossification is bilaterally symmetrical. 3. Variation in the

ossification of bones is a hereditable trait.

At the same time another investigator, Rotch (1909), developed a concept of major importance. Rotch was concerned because he found a child's chronological age to be a poor indication of developmental status, and moreover he could not derive many additional valuable information from height, weight, or number of teeth. He came to the conclusion that in the developmental process, from birth to adolescence, the normal changes which take place in the wrist, compared closely to other joints in the majority of individuals, can be accepted as a fairly accurate index of general development.

Rotch (1909) also presented the idea that in order to have a truly accurate indication of developmental status, the clinician can take into account the number of centers in the carpus together with the primary and secondary bony centers of the radius and ulna, made visible by roentgenography. After that he encountered the problem of measurement, and he provided his own system of assessment which was superseded later by other more complete methods. Because his method was based on physical observations and its goal was to supersede, or at least to supplement, true age status in the evaluation of the developing child, he first gave to his concept the name "anatomic age".

The Assessment of Skeletal Maturity

In the beginning the problem was to measure stage by stage metamorphosis of the cartilaginous and membranous skeleton of the fetus into the fully ossified bones of the adult. In the female, approximately 19 to 20 years pass between conception and the age when this process is likely to be completed. The same process takes about three years longer in the average male.

We can divide this 20 year period into three very distinct phases. The first includes the ossification of the diaphyses of the long and short bones of the hand, and is practically completed in utero. The second, which starts just before birth, is osteogenesis in the epiphyses of these shafted bones, and also in the appendicular skeleton. The second phase is completed by puberty, meaning that in duration the average girl is approximately 12 years old. However, in some bones of both sexes this phase does not start until puberty or later, meaning that it coincides with the third phase. The third or final phase is the one where we can observe osseous invasion and replacement of the growth cartilage plates. This invasion leads to the functional destruction of the cartilage plates and the bony fusion of the epiphysis with diaphysis. This phase starts with the onset of the puberty and is completed in the average

female appendicular skeleton by the seventeenth year, and in the entire female skeleton, approximately two to three years later.

Phase I has been the subject of histological studies by O'Rahilly and his colleagues (1957, 1959, 1960) and it has also been studied radiologically (Pryor, 1923; Flecket, 1942; Chistie, 1949; Christie et al., 1950; O'Rahilly and Meyer, 1956).

Pryor (1923), after studying aborted fetuses, came to the conclusion that the female is in advance of the male from the earliest development of centers of ossification in the embryo. However, we understand how difficult it is to study this fetal phase, knowing the certain hazards involved in exposing the unborn fetus to x-rays.

Prior to 1936, early methods of assessing skeletal maturity took two distinct forms. The first of these, introduced by Rotch (1909), and further developed by Bardeen (1921), was concerned principally with the hand. Rotch's main concern was the first appearance of calcification in bony centers in the carpals, radius and ulna. He gave the description of 13 stages or categories of maturity. however rotch did not give analytical thoughts to the changes undergone in an individual carpal center between the earliest preliminary calcification and maturity, nor the invasion of the growth cartilage.

also, there were some years immediately before puberty for which the differentiation made possible by this method was poor.

Bardeen (1921) attempted to overcome this difficulty by allocating to each separate developing carpal center one of four letters. " d " designated a center so newly calcified as to be barely visible. "a" symbolized a large dense center and "c" and "b" were intermediate. afterwards, bordeen combined these groups into overall stages of a carpal development. He defined, in all, 11 such stages but confined his descriptions entirely to the carpus, without including the radius and ulna.

The failure of these investigators to appreciate the significance of pryor's finding, together with other reasons, resulted in the overall failure of the above mentioned procedures. more specifically these procedures did not appreciate the large part played by the genetic factors in determining the order of ossification of the bony centers. Furthermore Bardeen was concentrating totally on the carpus, which consists of round bones and cannot represent other bones of the skeleton which may represent another pattern of growth and maturation.
Trying to surpass the problem of variation in the order of appearance of bones, and taking into account the procedure of osteogenesis between the initial stages of calcification and the achievement of maturity, many

authors made direct measurements of the amount of relevant bony tissue on the x-ray (Lowell and Woodrow, 1922; Carter, 1926; Flory, 1936).

A third method has been supported which utilizes x-rays of several joints to judge "bone age" from the epiphysis in which ossification had just begun.

Atlases

Hellman (1928) presented a detailed description of the changes in radiographic appearance undergone by a growth cartilage plate during the process of fusion of the epiphysis with the diaphysis. Todd called them "determinators of maturity". He started describing equivalent changes, first in the short and long bones before the ossification of the growth cartilage plate, and later in the bones throughout their period of development. He defined maturity determinators as "successive changes in outline...and contour". In 1950, Greulich and Pyle clarified this important concept in the following terms: "Maturity indicators are those features of individual bones that can be seen in the roentgenograms and which because they tend to occur regularly and in a definitive and irreversible order, mark their progress toward maturity".

After this step was performed, the assessor became able, by simple inspection, to judge the development of each center by studying the shape of the shadows, cast

from the newly forming bony tissues as it replaced the radiotranslucent cartilage. However, he did not have to search from one joint to another to find a newly ossified center, in order to gain a measure of the maturity, neither did he record the size of an ossific shadow.

Knowing that determinators by themselves were insufficient, Todd felt that it was necessary to relate them to what could be expected in the normal child. To do this, Todd (1937) decided to "produce" an integrated picture of the maturation process in each anatomical area he was studying. However, before engaging upon integration he examined the maturation of each developing center separately. As a basis for his work he examined a population of healthy children of all ages, from prosperous homes in Cleveland, Ohio. (details concerning the sample will be given later)

He divided the sample in groups, and then for each age group, the most suitable films of healthy children were chosen. These were arranged, one bone at a time, in the order of increasing maturity, and the film showing the bone of median maturity for the age group was selected. Then, he described the maturity determinators of the bone concerned, and these were taken as typical of the development to be expected of any healthy child of that particular age and sex. After that, the series of

films were re-examined trying to find standards according to which for each age and sex, every individual bone was precisely at the median stage of development.

Finally to each of these chosen films, he assigned a "skeletal age" and this was determined by the age of the children upon whom the standard was based.

Their original hand atlas has been revised twice by Greulich and Pyle (1950, 1959). They had also published atlases of the foot and knee, based on the same population of children. However, we have to remember that, even if the aspects of pattern and rate of maturation are under genetic control, they can be modified by a variety of environmental factors, of which disease and under-nutrition are probably the most important (Acheson, 1966).

As the child approaches maturity, there are many characteristic changes in the profile which are common to all the patients. For instance the mandible becomes longer, thicker and more prominent relative to the front of the face. Both jaws tend to become more prognathic with the mandible more so than the maxilla, resulting in a straighter profile, with a more prominent chin. Upper and lower incisors assume a more upright position, and a more forward and downward position of the nose results, due to its accelerated growth during this period (Tanner, 1955).

It is important for the orthodontist to supervise facial growth not only during the rapid period of development but also later, after maturity is reached and deceleration of growth is observed. The ability of the clinician to predict when these changes are to occur can help him to maximize or redirect some growth tendencies, resulting in a better result for his treatment.

Craniofacial skeleton remodeling has been extensively studied in the adolescent (Hoyte and Enlow, 1966; Enlow, 1968) up to the age of twenties (Linder-Aronson et al., 1975). Behrents (1985) studied remodeling activity during post-maturational aging and said that it can be analogous to that occurring during adolescence, except for the rate of change, and the demand usually placed on this mechanism. Perhaps the best description of the overall mechanism involved in craniofacial growth for the adult was given by Enlow (1982).

In all tissues and organs, growth introduces a continuous series of "localized imbalances" and there is a sequential but essential simultaneous leap-frogging of small level, catch-up growth changes. Growth is a continued process of part-by-part, region-by-region, striving toward a state of ultimate equilibrium. When such craniofacial-wide (and body-wide) balance becomes attained, growth itself is essentially complete. Should

some intrinsic or extensive change be introduced at any local tissue level, the growth process is reactivated, and tissue proliferation and differentiation provide for transient or short term growth and remodeling sufficient to restore a state of equilibrium, be it biomechanical, bioelectric, physiological, hormonal, vascular, neurological, or otherwise. In this restricted sense, the endothermic mammalian body like that of the ectothermic reptile, continues to "grow" throughout life.

Baer(1956) believes the distinction between childhood and adulthood is arbitrary. Behrents (1985) concluded that growth as defined continues, and he finds that the ability of cells, tissues and organs to produce change in the craniofacial complex ceases perhaps only at death.

Knowing that change does occur during adulthood the importance of Behrent's study lies in the amount of change seen and its clinical importance.

Behrents (1985) found considerable craniofacial alteration beyond 17 years of age. Growth of the craniofacial skeleton continued into the oldest age spans but in a decelerating manner. Although differential change was evident, he found that in young adulthood the directions of growth were specific to the individual and his/her sex. Vertical dimensional change appeared common to both sexes in late adulthood. Growth of males

differed from that of females because: females were smaller at all ages, grew less, grew in a more vertical direction, and mandibular rotations were seen in a posterior direction. Also an apparent deceleration of growth in the females in the teen years was followed by increased activity in the twenties.

In addition to this, sexual dimorphism was apparent, especially in the region of the orbit, with the females demonstrating a more upright and superior orientation. Finally, as expected, soft tissue changes were of greater magnitude than skeletal, primarily involving elongation of the nose, flattening of the lips and augmentation of the chin.

The majority of research aimed at the prediction of craniofacial growth has been directed at measuring the physiological or developmental status of individuals. Four methods have been commonly used for the assessment of the developmental age of a growing individual. These are: gross morphological changes (weight, height, etc.), skeletal assessment, dental assessment and secondary sex characteristics.

Morphological Changes

Orthodontics embodies the study of the growth and development of the dentofacial complex particularly, and the growth and development of the body generally. So we conclude that over-all growth and development should be

considered as one of the most important considerations in orthodontics. Green (1961) stated that the early prevention and interception of dentofacial deformities depends upon a precise interpretation of the inherent facioskeletal pattern and the overall growth and development. Greulich (1950) came to the conclusion that "Growth manifests itself by an increase in mass and volume as disclosed by an increase in weight and by changes in external dimensions as the child advances in age." Development is the expression of those processes by means of which the child becomes progressively more mature. While growth and development proceed concomitantly in the normal child, they are to some degree potentially independent processes. Increases in weight and skeletal height represent morphological changes. However, they both express growth and therefore they are poor indicators of the developmental age. As Tanner (1962) states, a child above average in height may either represent a more mature individual or just a tall individual now and in the future.

The accuracy of height and weight to accurately determine the developmental status is doubtful because of extensive heterogenity of today's populations. Greulich and Pyle (1959) contend that what is considered normal for one nationality may not be for another. Another factor that can amplify this diversity and change is that

normal weight and height values for one group can be totally inapplicable to another due, for example, to is the diverse diet one can find among different nationalities.

Although height and weight do not appear to represent maturational status accurately, considerable research has been directed toward correlating the adolescent facial growth peak with a similar peak in standing height.

Hunter (1966), trying to see if facial growth was correlated with growth in height during and after the pubertal growth period, found that maximum facial growth was coincident with maximum growth in height in the majority of subjects in his study (34 females and 25 males). This finding was contrary to the observations of previous investigators. It appeared also that facial growth in females was more likely to have been completed at the time of final body height than in males. Johnston et al (1965) asked the following question: does skeletal maturation play a part in cephalofacial development which makes its use desirable as an indicator of maturation level? They concluded that skeletal maturation and especially mandibular growth become factors which account for a significant portion of the variation in cephalofacial structure among children.

Again Singh, Savara, and Newman (1967) and Fukuhara

and Matsumoto (1968) attributed a high degree of association of the adolescent facial growth peak to a similar peak in standing height whereas Nanda (1955) and Bambha (1961) have stated that the peak of facial growth, although closely associated with the stature peak, usually occurs at a slightly later time (9-12 months later). Also Singh, Savara and Miller (1967) and Hunter, Balbach and Lamphiear (1940) found that the length of the mandible was highly correlated with other body measurements and appeared to be the most consistently inherited characteristics of several measured facial dimensions.

Bushra (1949) and Lindegard (1953) had also found a high degree of association of facial growth with general body growth (stature, standing height, shoulder width, etc.), while other studies like those of Howells (1952), Kose (1953), Meridith (1962), Savarra (1963), and Haghley (1954) showed again a low degree of association. On the other hand Bjork and Helm (1961) found that there was a possibility of predicting the age at maximum puberal growth in body height from other criteria of maturation. One of these criteria was the age when ossification of the ulnar metacarpophalangeal sesamoid of the thumb occurs. A high or moderately high degree of correlation between total carpal area and each of four physical traits, height, weight, width of shoulders, and width of

hips, was shown for ages 10 to 16 years for the boys, and 8 to 12 for the girls (Baldwin, Busby, and Gaerside, 1928).

Hewitt and Acheson (1961) found that rapid maturation of the skeleton tends to be associated with less than average height. Within each sex this is particularly offset by an overlap between the factors determining the rates of growth and maturation, and also by the tendency for children with early puberty to undergo a more intensive growth acceleration. Between sexes, however, we do not see these "compensating" mechanisms. Rapid femoral maturation of girls is not accompanied by more rapid growth, nor does their earlier puberty entail a greater growth spurt than boys. In girls acceleration in skeletal maturity is less sharply associated with maximum height acceleration than in boys, but a close time relationship between the two also exists.

Although stature during childhood may be the same for a group, the individual who has the early maximum rate of growth will be the shorter adult (Boas, 1932). It also has been stated that children with feminine contours or a broad-body build mature earlier than the slender or more masculine children (Pryor, 1936; Stuart, 1947). Bergensen (1972) concludes from his investigation that a significant correlation exists between the onset

of the male adolescent spurt of all facial dimensions studied and standing height. He also found that skeletal maturation is significantly correlated with the onset of the male adolescent growth spurt.

So, we can say that morphological changes, such as increases in height and weight, are excellent indicators of growth, but doubtful in their assessment of physiological maturity. Various investigators provide conflicting findings with higher or lower correlations!

This lack of agreement further demonstrates that morphological changes would not be a precise predictor of craniofacial development.

Dental Assessment

The stage of dental development is determined by the order of appearance, size, and amount of calcification of the tooth buds; deciduous tooth eruption; progress of calcification of the permanent buds; deciduous tooth resorption; permanent tooth eruption; and closure of the orfices of the permanent teeth (Schour and Massler, 1941).

The development and eruption of teeth are a part of the child's total development. Dental developmental schedules are used as indices of growth and maturation during childhood since teeth develop and erupt in characteristic sequences and within predictable age ranges (Massler, 1941; Nelson, 1959; Schour and Massler

1941; Watchon and Lowery 1954). A reliable dental assessment technique that could give us a precise estimation of the patient's maturational status would be more than welcome from an orthodontic aspect. Having the dentition in the craniofacial complex, examination and estimation of facial growth and developmental age could be done in the same time with minimal radiation exposure for the patient. The practicality of the subject and the positive correlation of dental development and maturational status, have encouraged many investigators to study this approach.

Logan and Kronfeld (1933), Nalla (1960) and Schour and Massler (1941) and many others came up with standards of dental development. Many studies have well documented the sequence of eruption and the stages of development of the dentition. However, we find conflicting information comparing the physiological maturity and the dentition, meaning the time of eruption or stage of calcification. Spier (1918) and Anderson, Thompson, and Popovich (1975) found a higher association between dental development and morphological development than between dental and skeletal development. Green (1961) agreed in his study with Hotz, Boulander and Weisshault (1959) that the degree of correlation was higher between dental age and chronological age than between dental and skeletal age. Green concluded that the best single predictor of dental

maturity was the chronological age. Hellman (1932) was one of the first to recognize the importance of developmental age, grouping children by eruptive stage rather than chronological age.

However, the many extrinsic factors operating to cause variation in eruptive time and sequence have made it largely unsatisfactory as an indicator of maturation level (Gray and Lamons, 1959; Green, 1961). Hughes (1958) emphasized the relationship between the growth of teeth and that of the basal bones, and their relationship in the growth pattern of the whole child. Shelling and Anderson (1936) said that the progress of dental development is subject in large measure, but not as an invariable rule, to the same factors that influence skeletal development and general systemic maturation. Three years later Stuart (1939) agreed that delay in dental development is usually, but not always, proportional to that in endochondral, skeletal, and general systemic retardation. Salzman (1954) stated that the knowledge of the factors most responsible for dental growth disturbances are of big importance in establishing a diagnosis, time for orthodontic intervention, and the type of treatment to be followed.

Lauterstein (1961), and Demish and Wartman (1956) found a high positive correlation between dental root age and skeletal age. Children with advanced root

development also had a corresponding advanced skeletal development. Japanese children have been found (Sutow, Terasaki and Ohwada, 1954) to have an overall tendency for a more mature skeletal development, being correlated with a more mature dental development. This demonstration was done when children of the same chronological age having advanced skeletal development had a greater number of erupted permanent teeth than those with a lesser skeletal development.

In another study in 1965, Moorees and Reed found that for the dentition, tooth emergence and eruption are more suitable as parameters of dental development than chronologic age in defining the changes in arch dimensions as they actually occur in the average child. (Except for arch length, the variances in the absolute intercanine distance as well as in the increments of both arch dimensions were not appreciably decreased, as was expected, in the more homogenous sample they used in their experiment.)

Lamons and Gray (1948) in a study of correlation of the hand and tooth development, investigated the agreement between the growth of those two parts of the same body and came to the conclusion that hand development and tooth development may vary independently. Krogman (1959) found a positive correlation between chronological age, skeletal and dental development, but

in contrast, Demish and Wartman (1956) and Bambha and Van Natta (1963) drew the opposite conclusions that there is no evidence of association between the time of tooth eruption and the time of skeletal maturation. Gron (1962) proposed that there is a higher degree of correlation between tooth emergence and the stage of root formation than between the tooth emergence-eruption and the chronologic or skeletal age of the child.

Again we arrive at the conclusion that because of the conflicting information, the correlation between the dental and the skeletal age seems to be low. Clinically, it appears that dental age is not a precise indicator of the maturational status of the child or of his rate of maturation. This, without implying that dental emergence and skeletal growth are not related, means only that the predictability is poor (Burstone, 1963).

Secondary Sex Characteristics

Adolescence is defined by Webster as "The state or process of growing up from childhood to manhood or womanhood; youth or the period of life between puberty and maturity." Near the beginning of the second decade of life, certain changes begin to occur which mark the onset of adolescence in both boys and girls. In girls, these changes occur 1-2 years earlier than in boys. We can observe an increase in size, while certain endocrine factors begin to enter into the picture producing complex

physical, physiological, and psychological changes. This period of growth and development is complete near the end of the decade, with boys sometimes later than in girls and continuing into the early twenties. In this way, the secondary sex characteristics appear in a consecutive way for most of the adolescents. This order of appearance of the secondary sex characteristics has been of interest to many people. Greulich stated in 1941, that in "normal" puberty in girls, breast changes are well underway before pubic hair is present in any quantity, and menarche is usually third, preceding axillary hair. Ellis (1946) said that in boys, pubic hair and genital development appear at approximately the same time, while axillary hair appears relatively late. One phase of sexual development that has received big attention from different investigators was the occurrence of menarche in girls. Simmons and Greulich (1943) and Deming (1957) found that the mean chronological age for menarche appears to be around 12 years, 8 months of age.

That was 6 months earlier than was found by Shuttleworth (1937) in the Harvard growth study, and approximately a year earlier than the mean age of menarche found by Abernathy (1925) and the Hebrew Orphan Asulum Study by Boas (1932).

Shuttleworth (1937), in his study of sexual maturation and physical growth in girls, concluded that

menarche is closely associated with physical size and onset of adolescence.

Greulich et al. (1942) stated that the usual development of the skeleton occurs concomitant with the presence of adequately functioning gonads and keeps pace with the external evidences of maturation of the child, as indicated by the secondary sex characteristics. On the average, it was found that girls who menstruate early have a mean skeletal age which is advanced over that of girls who have an average menarche. These girls in turn have a skeletal age which is advanced over the late group. According to Flory (1936), in no instance did menarche occur before ossification of the first metacarpal sesamoid. In his series, the average age at menarche was two years later. Therefore, he felt that the appearance on x-ray of the first metacarpal sesamoid becomes a fairly securate way of predicting the time of puberty.

Todd (1930) demonstrated that the majority of females have their first menstruation between the age of 13 years, 6 months, and 14 years of age. He thought that the developmental age and not the chronological age is (highly) correlated to menstruation.

Therefore, he concluded that early maturers would have the tendency to have an earlier than average onset of menarche. It has been generally accepted that the large

girl is the early-maturing girl and the small girl is the late maturing one.

This premise did not hold true in the study of Hansman and Maresh (1961) who found that early-maturity girls tend to have their menarches at an earlier skeletal age, even though this age is accelerated over their chronological age, than do the later maturing girls. This relationship suggested a mutiplicity of factors upon which the growing-up process is based. Also, they found a slightly different sequence through which the secondary characteristics occurred. This was: (1) the pubic hair; (2) the breast changes (areolar and corporal), (3) the axillary hair; and (4) the menarche. For the boys pubic hair usually appeared only slightly earlier than the first genital enlargement, but axillary hair did not appear until approximately one year later. Menarche does not occur before ossification of the ulnar sesamoid, and was recorded up to a few years later (Bjork and Helm, 1967; Frisancho, Garn and Rohman, 1969). According to Simmons and Greulich (1943), Deming (1957) and Bjork and Helm (1967), menarche occurs on an average, at 11 years, 2.5 months after maximum pubertal growth.

Therefore they arrived at the conclusion that occurrence of menarche is quick evidence that the peak of the pubertal growth has been attained or surpassed, and after that we are expecting a deceleration of growth. It

is shown from Hewitt and Acheson (1961) that in girls the pubertal acceleration of stature gain is maximal approximately 18 months before menarche. In boys the acceleration is followed by the attainment of maturity for the innominate bone. In both sexes this acceleration is much bigger for early maturers.

Again Simmons and Greulich (1943) believed that skeletal age is more highly correlated with menarcheal age than with standing height or weight. For the years prior to menarche, and before the final adult stature is reached, a definite tendency for females with early menarches was shown to be considerably taller than females with late menarches. According to them the early maturer has a greater growth potential remaining after menarche than the late maturer. Finally, Howard (1928) found that the onset of menstruation varies between various nationalities, populations, and climates, and so are our estimations and correlations with the maturational status of these populations.

As previously indicated and discussed, suggestions deriving from the onset of secondary sex characteristics show us that most likely a skeletal growth spurt has been achieved and maturity has probably been attained. However, sexual development is a rather poor predictor of craniofacial growth, primarily because of the lack of precision it demonstrates, and secondly because, for the

orthodontist, evaluation of secondary sex characteristics is neither practical nor definitive.

Shuttleworth (1937) stated that after the spurt in height, growth is near its end and that menarche is an indication that growth is slowing rapidly.

Skeletal Assessment

Skeletal age assessment of children has become an accepted technique for determining the maturation level of an individual. Serial assessments of skeletal age, when considered in relation to chronologic age, can indicate a child's past rate of skeletal maturation. In addition they may indicate the future rate of maturation and allow predictions of the child's skeletal age at a future chronologic age. On the other hand, reliable predictions of skeletal age would assist in selecting patients for therapy and for the analysis of possible effects of therapy, illness, or altered nutrition (Roche, Davillon, Lyman, 1971), as mentioned previously.

From 1908 Rotch was seeking a method for rating the development of children because chronological age no longer seemed to represent a precise measurement of maturational level. This time, it was felt that the child should not be "pressed" to fit the average level, but rather should be guided to seek his own maturation level at his own rate. Hansman and Maresh (1961) felt that, as physiological and anatomical development seem to

take place in the same time, anatomical development as represented by the skeleton could represent the best available standard.

There are many reasons why the skeleton offers the best evidence of maturation. 1. The beginning and end points are established (only a few centers of ossification are present in the newborn, while the mature adult has complete epiphyseal union). 2. The continuous changes of the growing skeleton can be quantitated. 3. Assessment of the skeletal maturation status is easy and can be done quickly with the help of available standards. 4. The most used hand-wrist area can be radiographed with minimum effort from the clinician, and with minimal radiation exposure for the patient.

Nelson (1959) and Watchon and Lowery (1954) said that the appearance and union of the different skeletal centers of ossification follow a fairly definite pattern and time schedule from birth to maturity. A roentgenographic study of these skeletal maturational processes provides a valuable criterion for the child's level of osseous maturation.

The establishment of the skeleton as that area which best provides a general estimate of the degree of maturity now seems to be essentially complete. Though there are methodological differences (Acheson 1954, Greulich and Pyle, 1959), this approach enjoys a

widespread use in both clinical and research areas. Skeletal maturation seems to "bridge" the lack of correlation of the growth events and measures of biological time, such as stature, height (Bagley and Pinneau, 1952) and menarche (Simmons and Greulich, 1943).

The method of skeletal maturity assessment is based upon those changes in the developing skeleton which can be easily viewed and evaluated on x-ray films of selected body areas. As a film is exposed, assuming proper attention to technical details, information concerning the developing skeleton is recorded. This information is an objective record of the maturity status of the skeleton at a single point in time, without presenting the sum of all events prior to the time that the x-ray was taken. Maturity, however is not a static concept. As Malina (1970) stated, it is, rather, dynamic and indicates the progress an individual is making towards the attainment of biological maturity. Krogman (1962) in evaluating this progress via x-ray films of selected areas, utilized three broad categories of information. The first is the initial appearance of specific bone centers on the x-ray film, which indicates the initial replacement of cartilage by bone in the particular skeletal elements involved. The second is the definition and characterization of the bones by gradual shape differentiation, so that adult forms become apparent. The

third, where appropriate, is the union or fusion of the epiphyses with their respective diaphyses and the attainment of adult contours and configurations in the round or irregular bones.

The skeletal maturity of the individual is known as bone age or skeletal age. The carpal area was found by Nelson (1959) to provide a useful index of skeletal maturation and has been frequently utilized because it is easily accessible and radiographs can be taken at a minimum expense and time. The wrist being an easily accessible part of the skeleton has long been used as representative of the total skeleton (Pryor, 1925). Many researchers also advocated the inclusion of other parts of the skeleton to achieve a more precise assessment of the maturational level. The foot, knee, shoulder, elbow and hip, have been used in succession.

However, the hand-wrist area always has remained the primary area for the information sought, which is the determination of skeletal maturation. Although studies on multiple areas of the skeleton provided a bigger source for precise appraisal, they became less feasible during that period. This was because of the additional time, the expense involved, the technical assistance required and especially the larger amount of radiation exposure (Cobb, 1971).

Moed, Wright, and Vandergaft (1962) found that the

hand and wrist area represents a very reliable area for growth and maturation studies since it contains many osseous nuclei within a small space. Smith (1975), however, realized that a sex difference must be considered in evaluating skeletal age from hand-wrist films. He attributed this to the great difference in hormonal balance between males and females which influences skeletal ossification, growth in body dimensions, and secondary sex-characteristics. He also maintained that unlike the chronological age, which can be determined precisely, hand-wrist skeletal ages have a margin of error, probably approximately 6 months in clinical settings. He also doubted the hand-wrist film value, saying that it only corresponds to a small component of the skeletal system, and this may not always be representative of the growth of the rest of the skeleton.

On the other hand, consider for example the 20 ossifying centers of carpus with highest predictive value in terms of age at appearance among the 73 postcranial centers intercorrelated by Garn et al. (1967). Of these 20 centers, 13 were in the hand for Fels females and 11 were in the hand for Fels males.

The left hand, including the lower forearm, is the area of choice today. It is the area which permits easy subject cooperation and can be repeated many times,

usually without objection from the patient. At the same time, it is convenient for the doctor and can be done really quickly, and usually without any assistance. Also, uniformity and clarity of the radiograph are easy to obtain, and standarization of the technique is simple to achieve.

Various methods are used in the assessment of skeletal maturity in the hand and wrist. Among them are: 1. Planimeter measurements of areas of carpal bones (Carter, 1926); 2. Diameters of carpal bones, metacarpals and epiphyses (Cattell, 1934); 3. The time of appearance of individual centers (Flencker, 1942; Pyle and Sontag, 1943; Garn and Rohmann, 1962; Garn, Rohmann and Appelbaum, 1961); 4. The number of ossification centers present (Buehl and Pyle, 1942; Francis, 1940; Sontag, Snell and Anderson, 1939; Acheson, 1954); and 5. Combinations involving number, size and extent of modeling of the ossification centers (Flory, 1936; Greulich and Pyle, 1959)

Todd (1937) like Greulich and Pyle (1959) were the first who introduced, the "atlas" or "inspectional method."

The atlas method, entails the matching of a given film as nearly as possible with a series of standard x-ray plates which correspond to successive levels of skeletal development at specified chronological ages.

The age identified as typical of the standard plate, with which a given child's film most closely coincides, represents the individual's skeletal age.

They concluded that examination of the number of centers of ossification, their degree of calcification, and the degree of epiphyseal union provide the most reliable method of assessing the skeletal age. Their method can give the indication of whether the maturational level is advanced, normal, or delayed as compared to these norms.

The Todd, and Greulich and Pyle standards are based on North-American children of European ancestry, from prosperous families, and selected on the basis of optimal health. Thus, most American and British children, who represent the middle or higher economic levels (Pyle and Menino, 1939; Acheson and Hewitt, 1954) can fall within the Todd and Greulich and Pyle categories. It has also been observed that the carpal age of non-whites, (Garn and Shamiz, 1958) frequently falls several years behind these two standards. Gray and Lamons (1959) proved that children coming from families with less than the median income for the city (Atlanta), presented a skeletal age behind the Greulich and Pyle standards and did not catch up until the age of 15 years.

Johnston (1963) in his study in Philadelphia, determined that both sexes matured more rapidly than

their chronological age equivalents in the Brush foundation. It should be noted that his sample was examined almost a generation after the Greulich and Pyle's children. That could give support (or the belief) toward the possibility of earlier maturation in succeeding generations.

Another method of assessing skeletal maturity was the "bony specific" approach, developed by Acheson, 1954, 1957; Tanner and Whitehouse, 1959; Tanner et al., 1962. It also is a matching method, but entails matching individual bones on a given film to a series of written criteria for standard stages through which each bone passes in its progress to the mature state. Each stage is assigned a specific point score and the result is a skeletal maturity score rather than a skeletal age.

When determining skeletal maturation we have to keep in mind that late maturing has not been considered bad, and neither has early maturation always been considered good (Garn, 1958). Different maturation rates, in different populations from various ethnic groups and nationalities, made it impossible to find and apply worldwide standards for skeletal maturation assessment.

An additional consideration is that one bony nucleus may be a far better indicator of ossification status than another. This has major importance when too much emphasis is placed on particular centers of ossification.

Sontag and Pyle (1943), like other investigators before them, were wondering about the variability of appearance of different centers of ossification. Some years later Greulich and Pyle (1950, 1959) and Fleckner (1942) made a list of the centers, presenting the greater variability in order of appearance.

Sontag and Reynolds (1944) and Reynolds (1943) held that the consequence of calcification is in high degree genetically determined. Therefore, biases by genetic factors could be a detrimental factor in the evaluation of osseous maturation when simply counting the centers of ossification. Garn and Rohmann (1960) showed the inadequacy of ossification order and proposed the probability of true population differences. Hewitt and Acheson (1961) mentioned that the peak velocity may vary from one growth area to another. This is explained on the basis that different areas of the human skeleton maturate at various rates which can vary from one time interval to another.

Recognizing the inherent limitations in using only one area of the body in maturity assessments, Garn and co-workers (Garn et al., 1961, 1964, 1967) concerned themselves with the appearance of ossification centers and epiphyseal union, eliminating the intermediate process of morphological characterization. He recommended utilization of three x-ray films to yield the

most objective information on the appearance of ossification centers during the first 10 years of life: a P-A film of the hand, an A-P film of the foot, and a lateral film of the knee. It should be noted that the foregoing is concerned only with the time of appearance of ossification centers, which is independent of the time of epiphyseal union and the rate of skeletal maturation. The information contained in the interval between appearance and union, which is basic to other approaches to skeletal maturity, was not utilized.

Despite some of the above mentioned problems, prediction and assessment of skeletal maturity from the hand-wrist radiograph has to date proven to be the best solution for the clinician.

However, in many investigations (Hewitt and Acheson, 1961; Shuttleworth, 1938; Nicholson and Hanley, 1953) have found skeletal age assessment (from the hand-wrist x-ray film) to be highly correlated with the stages of physical and sexual maturity. Pryor (1923) was the first to conclude that girls maturate at an advanced rate compared to boys. According to his findings a difference in the rate of ossification exists which is relatively small initially, increases during childhood and puberty, and then, a deceleration period occurs as maturity is being reached.

Baylen (1945) believed that the mature size of a

child can be predicted with fair accuracy if present size and skeletal age are known.

The study of Bambha and Van Natta (1963), consisted of longitudinal data on skeletal maturation and facial growth. They found an association between the skeletal maturation and the facial growth during adolescence. They stated that individuals who tend to mature early with advanced skeletal age have an earlier adolescent facial growth spurt, whereas the children with retarded skeletal maturation tend to mature later.

They also said that although the statistics demonstrate the general tendency, the orthodontist's prediction cannot be so accurate because of the individual variations found.

Numerous studies have tried to correlate facial growth to chronological or skeletal age. In describing facial growth there are usually two important points to consider: 1. the increments or intensity of growth, and 2. the direction of growth.

For instance, Moreschi (1964), in his longitudinal study based on the lateral head films and the left hand films of 20 Caucasian girls with normal occlusion, found that measurements which follow skeletal age most closely were S-Na, S-Pr, Ar-Go and Go-Gn. Others apparently unrelated to skeletal age were S-Gn, Ar-Pr and Na-Gn. After that, he concluded that the upper face depth and

height with the ramal height and the carpal length are ruled by biologic age. In contrast, the position of the mandible to cranial base (S-Gn), to face depth (Ar-Pr), and to the total face height do not seem to be affected by the skeletal age.

The timing and rate, also, of the pubertal spurt of facial growth have been studied by many investigators. Menarche was found by Shuttleworth (1938) as an indication of completion of growth in height.

From a study of correlation between facial growth and body height, Hunter (1966) concluded that, among all the dimensions studied, mandibular length showed the most consistent relationship with growth in height. A definitive circumpubertal growth spurt of the face occurring just after the spurt in body height was found by Bambha (1963). He also found that the various facial dimensions studied followed the same curve of growth of stature. The time of the onset and the peak of the growth spurt showed great individual variability.

Comparison of the mean annual increments for all the four dimensions studied in the mandible (Dolan, 1967; Harris, 1962; Maj and Luzi, 1962; Meredith, 1961; Namda, 1955; Newman and Meridith, 1956; Tracy and Savara, 1966; and Woods, 1950) revealed a common pattern. This was a rapid deceleration of growth in the early years of life (with sometimes a mild acceleration in early childhood,

and a preadolescent period of deceleration), followed by a circumpubertal spurt of growth.

The amount of growth and the timing of the maximum increment are variable between sexes and among individuals.

Tofani (1972) found that the growth of the mandible continues after menarche. She found also that a significant difference exists between the amount of growth before and after menarche.

The average amount of growth in the four mandibular dimensions studied was usually greater before menarche than after. Another interesting finding was that menarche most often occurred after the maximum increment of growth in the mandible in the early- and average-maturing groups of girls and before the maximum increment in the late-maturing girls. Also onset of fusion in the distal phalanges of the fingers was highly correlated with menarche.

In the effort to achieve precise assessment of the skeletal age, considerable attention has been given to the sesamoid bone of the hand.

Flory (1936) stated that 50% of the girls in his series showed ossification of the sesamoid near the distal end of the first metacarpal at 11 years of age and 50% of the boys at the age of 13 years.

Francis (1940) in his study of appearance of centers

of ossification in a sample of healthy children from stable socio-economic level families in Cleveland, aged from 6 to 15 years, tended to agree with Flory, concerning the time of ossification of the tendon of the plexor pollicis brevis. He found also that sesamoid bones are more numerous in the girls at 15 years of age than in boys. He did not believe that was actually a sex limited difference, but in his opinion was due to the fact that at the chronological age, girls are physically more mature than boys. Referring to the timing of appearance of centers of ossification, he stressed the fact that in the interval from birth to 5 years of age, centers of ossification appear in groups. In contrast, from 6 to 15 years of age, a much smaller group of centers begins to ossify, and the age interval is twice as long. Therefore, in most instances, ossification appears in one center at a time.

Garn and Rohman in their study in 1961 investigated the age at union of digital and metacarpal epiphyses in serial hand radiographs of 107 Caucasian, Ohio-born children. They found that girls were advanced over boys by 13% in complete hand union, a value considerably smaller than the extent of sexual dimorphism in the knee, or in the appearance of ossification centers in general. No relationship was found between the order of appearance of the 19 digital and metacarpal epiphyses and the

sequence of union, or between the time of appearance of these centers and the time of union.

The same investigators, one year later (1962) in their study regarding the age of appearance of the adductor sesamoid of the thumb, came to the conclusion that the median age of appearance was 10.5 years in girls and 12.6 years in boys, representing a 17% maturity difference. Correlations with the ages of appearance of round bones were low, whereas correlations with both epiphyseal union and menarche were moderate. Another finding was that, from children with non-functional gonads, the timing of this bone proved to be steroid-mediated but not steroid limited.

Buehl and Pyle (1942) concluded that the age at onset of ossification in the distal epiphyses of the ulna, and also the crest of the ulna, the first sesamoid of the thumb and the crest of the ilium, provides as reliable a measure of maturity as the concomitant mean total skeletal age, in the group studied. In addition they found that ossification began in these three centers according to the normal order of general development peculiar to each sex, i.e.; that boys follow girls in sequence of ossification.

So, we understand that the primary reason for the extensive research conducted on this particular bone is because the adductor sesamoid represents the only

ossification center in the hand that appears near puberty.

Garn and Rohman (1962), Chapman (1972) and Pileski, Woodside and James (1973), directed their studies toward the determination of the median age of sesamoid ossification. They agreed that the time of ossification of the sesamoid bone in females is 10 to 11.5 and years of age, while in males it is between 12 and 14.5 years of age.

Chapman (1972) concluded that the onset of ossification of the sesamoid takes place at the time the adolescent spurt in statural height begins. Maximum growth in statural height never occurs before this ossification.

Bjork and Helm (1967) found that peak velocity occurs approximately one year after ossification of the ulnar sesamoid of the thumb.

Skeletal age assessment and its application to craniofacial development has proven a great help to the orthodontist in predicting facial growth. Assessment of individual's maturity by this method enables the clinician to evaluate optimum treatment time with the highest possible accuracy.

However, the successful management of any orthodontic problem is dependent upon a proper balance between theory and performance. An understanding of the

growth characteristics of the individual patient is essential to the most skillful treatment procedures if the ultimate clinical result is to be achieved.

STATEMENT OF THESIS

In this study an attempt was made to evaluate the reliability of the hand-wrist radiograph and the ossification of the carpal bones, in assessing the skeletal maturity and its consequences in the orthodontic versus surgical treatment (for severe cases) of the newly adult patient.

The determination of chronological age, dental age, and skeletal age are basic elements of the diagnostic procedures that are needed to decide which treatment method is to be instituted-with skeletal age becoming a highly significant factor in the evaluation of particular types of malocclusion.

It is a well known fact that children grow at varying rates and, that in general, we can determine or differentiate the moderate maturational schedule from patterns of either extremely rapid or very slow skeletal development. It, therefore, becomes evident that in correlating individual "biological clocks" to types of malocclusions or assessments of skeletal maturation can be extremely valuable and can affect the choice of treatment.

As the patient is approaching adolescence, the clinician is attempting to coordinate his treatment mechanics with the craniofacial growth pattern of the

patient and its pubertal growth spurt. After the patient reached adulthood treatment is primarily concerned with the correction of malocclusion and only in extreme cases the surgical correction is attempted since there is no significant growth present.

The primary method of determining the physiological maturity of the patient, is the skeletal age assessment. This assessmet will provide information which helps to determine the skeletal maturation.

The present study examines the hand-wrist film as the determining factor for the skeletal maturity. For this examination increments of growth were compared two years before and subsequently two and four years after adulthood was reached, in order to find if there is a significant change over time for the male and female population. In a part of the study, also, an objective was to identify any possible time and sex interaction or correlation that could exist within the sample population.

MATERIALS AND METHODS

In this study, x-rays from the Bolton-Brush Growth Study of Cleveland children (from 1931-1976), were used (families of average or above in economical and educational status). All of the children were Caucasian Americans of North European ancestry. They were examined every three months for the first postnatal year, after which they were examined every 6 months, from the age of 12 months until the age of 6 years. Subsequently they were examined annually.

At each examination the child was measured and weighed. The Brush records included:

a. Radiographs of epiphyses, left shoulder, elbow, hand and wrist, hip, knee, and ankle-foot, and frontal and lateral head films.

b. Psychological tests and a health history covering the period since the previous examination was obtained from the parents and the family physician.

c. A nutritional history for each individual and neuromotor, strength and dexterity tests.

d. Anthropometric measurements and electroencephalograms.

The Bolton records comprise frontal and lateral cephalograms and also dental study casts. The growth

studies were conducted from birth to adulthood.

Methods of Superimposition of Serial Head-films

a. Bolton plane with registration point-Broadbent

b. S-Na plane-Brodie

Broadbent developed the Bolton plane because it represented to him the entire cranial base and because he found that sella turcica moved upward and backward in relationship to the "R" point during growth. Brodie (1941) used the S-Na plane because it represented to him the anterior cranial base to which the face is "hafted" and is formed by two readily located landmarks. It might be pointed out that if sella rises during growth in relationship in point "R" it follows that point "R" descends down and forward during growth in relation to sella. In the present study the first method of superimposition has been used, and the dependent variables are the growth changes.

Method of Recording

The growth changes were recorded from oriented roentgenograms. Two views were utilized: the lateral film and the anterio-posterior film. Both views were taken with the teeth in occlusion. The details of this procedure have been discussed by Broadbent (1931) and Brodie (1941) and therefore are not detailed here. The apparatus used for taking the cephalograms was the

Broadbent-Bolton cephalometer with the standard 5 foot distance between the x-ray source and the midsagittal plane of the patient (lateral), and the porionic axis (frontal). The head was fixed in Frankfort Horizontal Relation. Tracings of both lateral and antero-posterior were made on 0.03 inch acetate paper with a fine pencil on a transilluminated tracing table. The tracings of the bilateral craniofacial structures of the lateral cephalogram were "averaged". To avoid distortion error, the midsagittal plane of the head was parallel to the film and the film was perpendicular to the central x-rays.

Fifteen cases (meaning 120 tracings), were retraced again after 2 months by the author, and a T-test to find the ratio of the mean and difference of the tracing error was made. For the data of the time interval T1 to T2, the errors were not significantly different from 0. For the time interval T2 to T4, again the errors were not significantly different from 0 except for the variables. \9\ Go-Gn (p=0,0470) and \19\ 1-Ba-Na (P=0,0589) where the P-value, as we see is fairly marginal, compared to the 0,05 level of significance. Again for the T4 to T6 time interval, except the variable \14\ SNB (p=0,0509: which is again fairly closed to the 0,05 level of significance), the rest of the variables didn't show any significant difference from 0.

PLATE I

The Broadbent-Bolton cephalometer

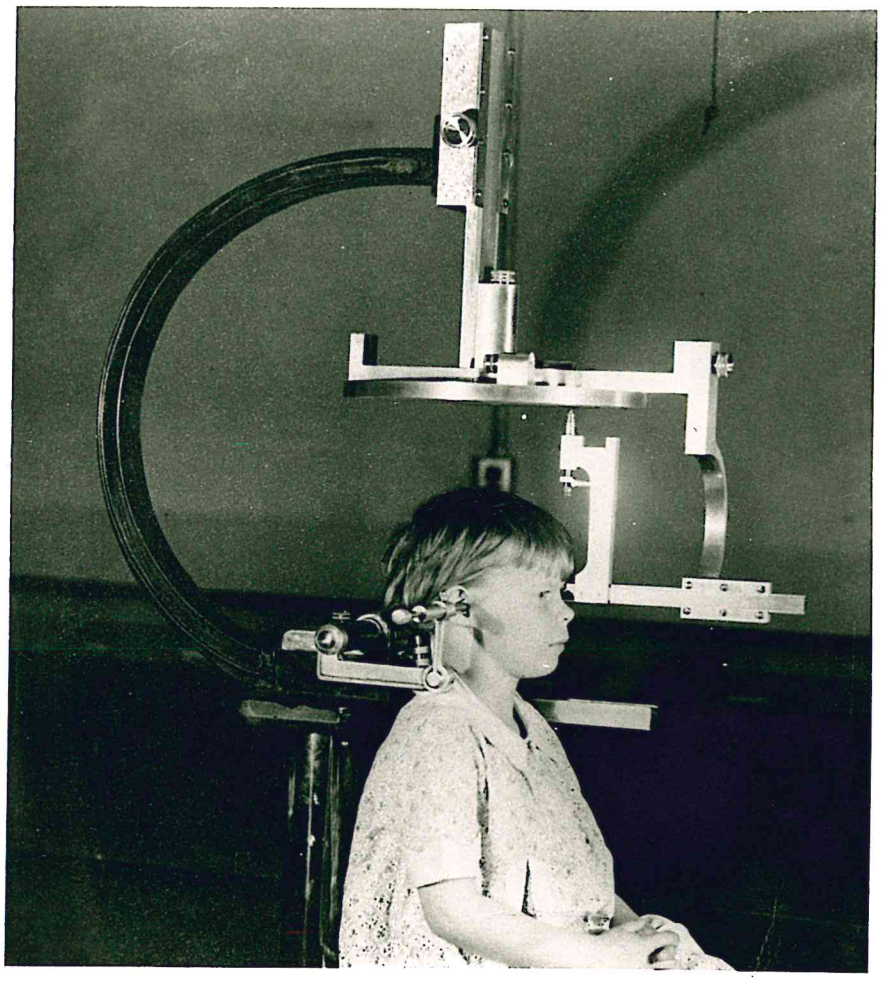


PLATE II

Bolton-Brush studies cephalometric and x-ray room

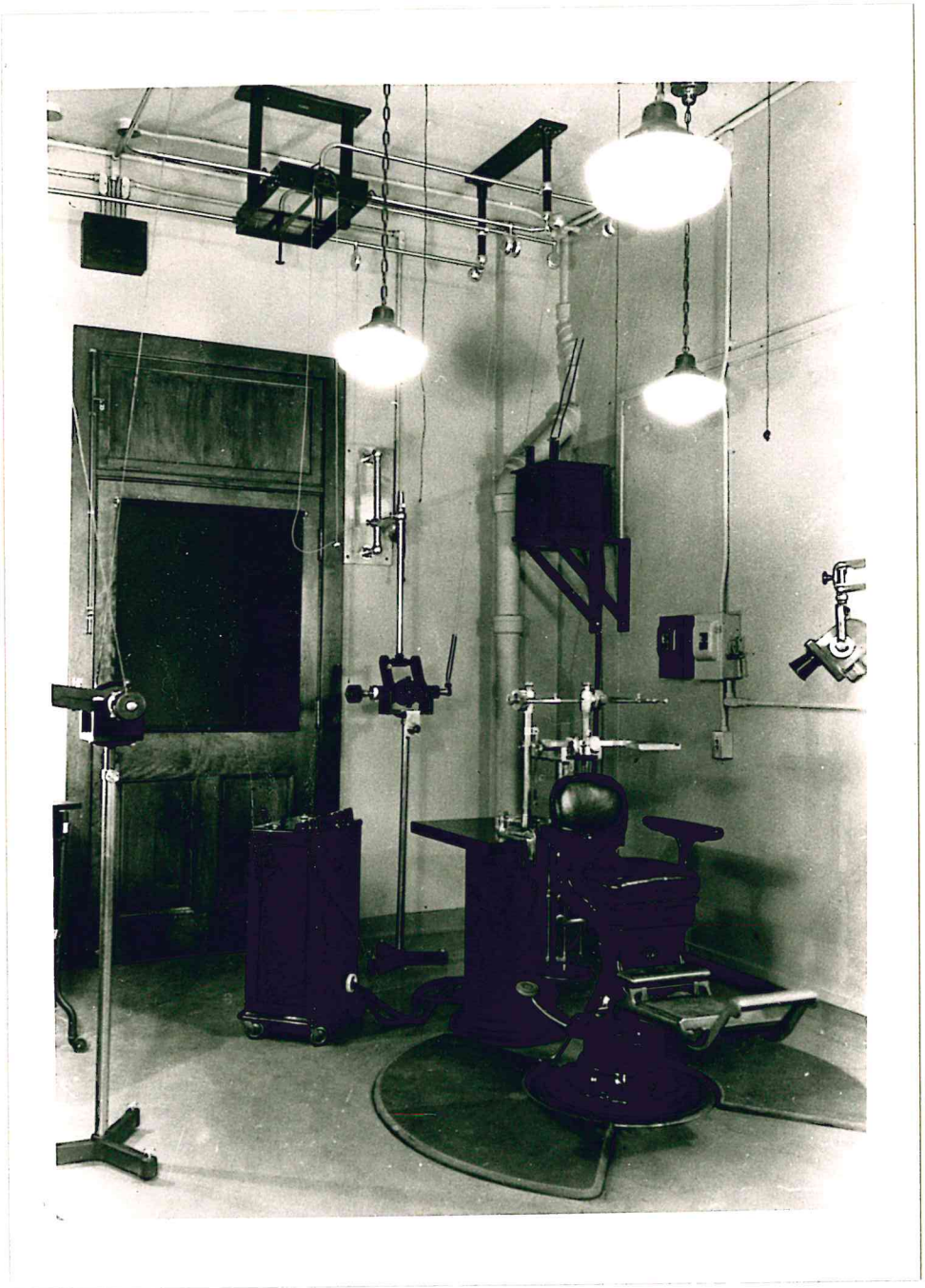


PLATE III

Hand-wrist radiographic film


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PLATE IV

Lateral cephalometric radiograph

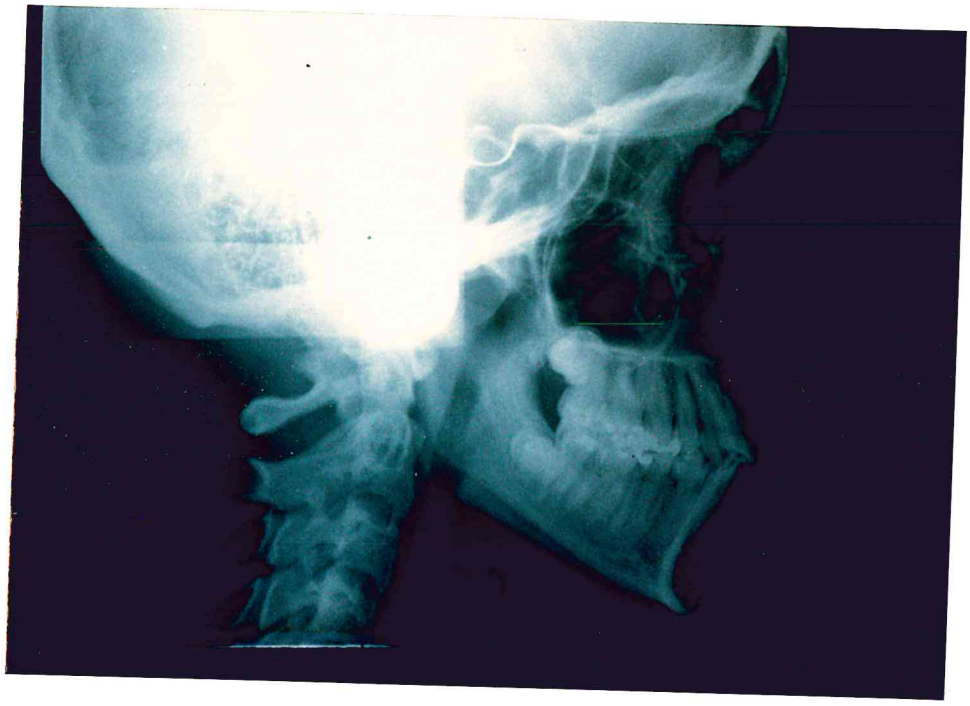
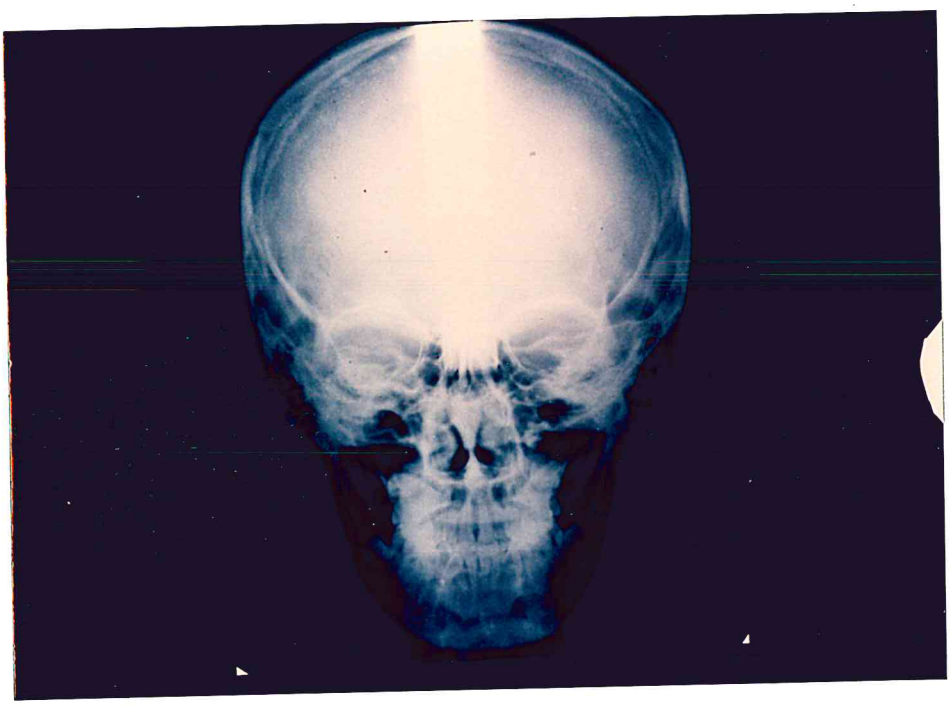


PLATE V

Frontal cephalometric radiograph



FINDINGS

In this study a Repeated Measures Analysis of Variance with one within factor (time), and one between factor (sex) was used to analyze statistically the data. The data is divided into two main parts.

The first part included a 3 time measurement. There the following time intervals were used. (Time 1 = 2 years before adulthood, Time 2 = adulthood and Time 4 = 2 years after adulthood). The second part included a fair time measurement which included the previous three time periods plus Time 6, which was four years after adulthood.

For reasons of abbreviating the data statistical symbols were used. An explanation of these symbols can be found on (Table 1). As zero (0) was defined any significant difference existing within the entire data. (0 = p value > 0.05).

TABLE 1

STATISTICAL SYMBOLS USED ON TABLES

T1	=	Measurements obtained 2 years before adulthood
T2	=	Adulthood
T4	=	Measurements obtained 2 years after adulthood
T6	=	Measurements obtained 4 years after adulthood
0	=	$p < 0.05$

$\bar{X}$ = Mean measurement

df = Degrees of freedom

T^2 = T - squeare test

p = Probability value

F = Power of probability - F statistics

* = Variables with statistical significant differences

For the simplified examination of the entire following questions were asked:

For the first part which include the three time measurement, the questions were:

1. Is there a sex difference? Is there a significant difference concerning the growth increments between the male and the female population?

2. Is there a change over time? Are there any significant differences concerning growth increments over the time intervals defined in this study?

If answers are positive, then the following questions are addressed.

a′ Is the difference between Time 1 and Time 2 significantly different from 0 ($p = < 0.05$)?

b′ Is the difference between Time 2 and Time 4 significantly different from 0 ($p = < 0.05$)?

3. Is there any time and sex interaction? Are the two genders having the same pattern of change over time?

If answers are positive, then the following

questions are raised:

a''. Do males and females have the same change from Time 1 to Time 2?

b''. Do males and females have the same change from Time 2 to Time 4?

Based on the three major questions listed the following statistical questions were intreoduced and rejected where the p-value ws lower than the 0.05 level of significance (0).

1: Is there a sex difference? $\bar{X}$ male $\neq$ $\bar{X}$ female

2: Is there a time effect? $\bar{X}1 - \bar{X}2 \neq 0$

$\bar{X}2 - \bar{X}4$

3: Is there significant change over time from 2 years before adulthood (Time 1) to adulthood (Time 2)? ($\bar{X}1 - \bar{X}2 \neq 0$).

4: Is there significant change over time from adulthood (Time 2) to 2 years after adulthood? (Time 4)?

5: Is there time and sex interaction, meaning that females and males have the same pattern of change over time.

6: Do males and females have the same change from 2 years before adulthood, to adulthood?
($\bar{X}1$ male - $\bar{X}2$ male $\neq$ $\bar{X}1$ female - $\bar{X}2$ female)

7: Do males and females have the same changes from adulthood to two years after adulthood?
($\bar{X}2$ male - $\bar{X}4$ male $\neq$ $\bar{X}2$ female - $\bar{X}4$ female)

Means and standard deviations of all variables are reported on tables 2 to 22.

As shown in the second column of the tables 2-22 and the first column of the comparative tables 23, 24, 25 of the three time measurements, the following statistical findings were made.

Sex Difference

1′ females and males have different measurements for the following variables. Those variables are placed in order from the most statistically significant different to the least statistically significant:

1. Ar-Go, 2. Ar-Gn, 3. Ba-Na, 4. PNS-ANS, 5. Go-Go
6. Zy-Zy, 7. S-Gn, 8. Na-ANS, 9. Go-Gn, 10. Na-Me
11. NP-AB, 12. N-A-P

Change Over Time

2′ Observing the second column of the tables 2-22 and the second column of the tables 23, 24, 25 it was found that 15 measurements changed significantly over time ($p < 0.05$). Again the order of significance is:

1. Na-ANS, 2. ANS-Me, 3. Na-Me, 4. Ar-Go, 5. S-Gn
6. Ar-Gn, 7. PNS-ANS, 8. Go-Gn, 9. S-N, 10. Go-Gn
11. Zy-Zy, 12. N-A-P, 13. NS-GoGn, 14. I-BaNa,
15. Ba-Na

The 6 measurements which did not seem to change significantly were:

1. ANB ($p = 0.1783$)

2. SNB (p = 0.3305)

3. NP-AB (p = 0.3519)

4. IMPA (p = 0.5579)

5. Interincisal (p = 0.6658)

6. SNA (p = 0.8832)

Among the 15 measurements which presented significant change over time only 4 variables listed below had significant change from Time 1 to Time 2 and no significant change from Time 2 to Time 4. The rest of the 11 variables have both significant change from Time 1 to Time 2 and from Time 2 to Time 4.

Observing the columns 4, 6 of the tables 23, 24, 25 we found the following:

VARIABLE	(TIME 1-TIME 2)		(TIME 2-TIME 4)	
I-BaNa	F1=11.00	p=0.0018	F1=0.39	p=0.5376
NS-GoGn	F1=9.25	p=0.0040	F1=0.04	p=0.8426
N-A-P	F1=7.76	p=0.0078	F1=1.00	p=0.3235
Ba-Na	F1=6.69	p=0.0125	F1=1.04	p=0.3127

Time and Sex Interaction

From the column 3, of the tables, 23, 24, 25 it is concluded that: except for the following three variables, 1. NS-GoGn (p = 0.0157), 2. Zy-Zy (p = 0.0287, 3. Go-Go (p = 0.0362), all of the measurements did not have time and sex interaction.

Trying to find which time interval this difference

occurred the individual contrast by sex was done (columns 5, 7 of the tables 23, 24, 25).

The individual contrast is summarized in the following table:

VARIABLE	(TIME 1–TIME 2 x SEX)	(TIME 2–TIME 4)
1. NS-GoGn	*p = 0.0085	p = 0.3957
2. Zy-Zy	*p = 0.0144	p = 0.0927
3. Go-Go	p = 0.2450	*p = 0.0120

Note: Significant differences are noted with asterisks (*)

In the second part of the study the 4 time measurement was used (2 yeasr before adulthood = Time 1; adulthood = Time 2; 2 years after adulthood = Time 4; 4 years after adulthood = Time 6).

The following questions were similar to the first part and were rejected if the p value was lower than the 0.05 level of significance.

1. Is there a sex difference?
2. Is there a change over time?

$$\bar{X}1 - \bar{X}2$$
$$\bar{X}1 - \bar{X}4$$
$$\bar{X}1 - \bar{X}6 = 0$$
$$\bar{X}2 - \bar{X}4$$
$$\bar{X}2 - \bar{X}6$$
$$\bar{X}4 - \bar{X}6$$

If this question is rejected the following individual contrast was tested to find which ones (at least one) are equal to -0-.

1. $\bar{X}1 - \bar{X}2 = 0$, 2. $\bar{X}1 - \bar{X}4 = 0$, 3. $\bar{X}1 - \bar{X}6 = 0$,

4. $\bar{X}2 - \bar{X}4 = 0$, 5. $\bar{X}2 - \bar{X}6 = 0$, 6. $\bar{X}4 - \bar{X}6 = 0$.

3. Is there a time and sex interaction?

If this initial hypothesis is rejected we test the following contrast to see which ones (at least one) are equal to 0.

1. $\bar{X}1$ male - $\bar{X}2$ male = $\bar{X}1$ female - $\bar{X}2$ female
2. $\bar{X}1$ male - $\bar{X}4$ male = $\bar{X}1$ female - $\bar{X}4$ female
3. $\bar{X}1$ male - $\bar{X}6$ male = $\bar{X}1$ female - $\bar{X}6$ fenale
4. $\bar{X}2$ male - $\bar{X}4$ male = $\bar{X}2$ female - $\bar{X}4$ female
5. $\bar{X}2$ male - $\bar{X}6$ male = $\bar{X}2$ female - $\bar{X}6$ female
6. $\bar{X}4$ male - $\bar{X}6$ male = $\bar{X}4$ female - $\bar{X}6$ female

From the first column of the Tables 2-22 and 26, 27, 28 it was concluded (concerning the 1st question) that the following 10 variables showed significant sex difference ($p = < 0.05$).

The variables are placed in order from the most statistically significant difference to the less statistically significant. 1. Na-ANS ($p = 0,0005$), 2. Ar-Go ($p = 0,0006$), 3. Go-Go ($p = 0,0024$), 4. PNS-ANS ($p = 0,0026$), 5. NP-AB ($p = 0,0033$), 6. Zy-Zy ($P = 0,0053$), 7. ANB ($p = 0,0103$), 8. Ba-Na ($p = 0,0329$), 9. NS-Go-Gn ($p = 0,0351$), 10. N-A-P (0,0479).

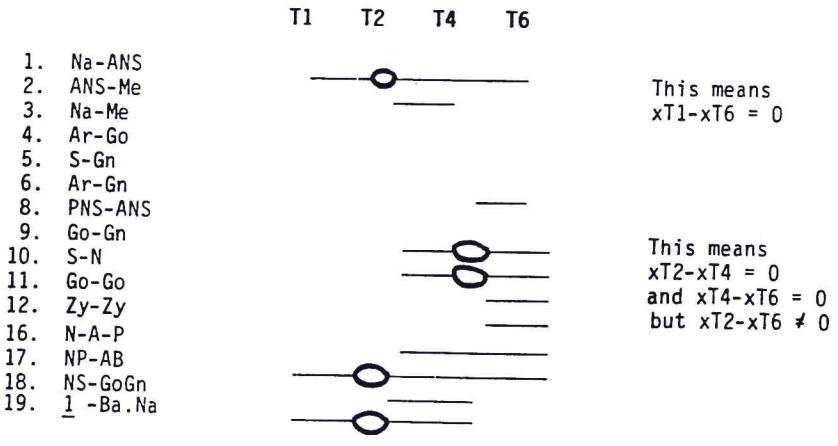
As seen in the 1st column of Tables 2-22 and the second column of Tables 26, 27, 28 it was found that for the second question 15 measurements showed significant statistical change over time (p = < 0.05). Again the order of significance is the following:

1. ANS-Me (p = 0,0000), 2. Na-Me (p = 0,0000), 3. S-Gn (p = 0,0000), 4. Go-Gn (p = 0,0000), 5. Zy-Zy (p = 0,0000), 6. Ar-Go (p = 0,0001), 7. Ar-Gn (p = 0,0001), 8. PNS-ANS (p = 0,0035), 9. GoGn (p = 0,0045), 10. I-Ba-Na (p = 0,0155), 11. NS-GoGn (p = 0,017), 12. N-A-P (0,0178), 13. Na-ANS (p = 0,0224), 14. S-N (p = 0,0433), 15. Np-AB (p = 0,0448).

The six measurements which did not seem to change over time were:

1. Interincisal angle (p = 0,2151), 2. SNB (p = 0,3534), 3. ANB (p = 0,4577), 4. Ba-Na (p = 0,4679), 5. IMPA (p = 0,7471), 6. SNA (p = 0,8355).

After individual contrasts were made for the measurements demonstrated significant change (a line was used to connect non-significant changes) fromt he columns 4-9 of the tables 26, 27, 28.



In summary of the third question:

a. Only two variables did not change significantly from Time 1 to Time 2.

b. Eight variables had no significant change from Time 2 to Time 4.

c. Eight variables had no significant change from Time 2 to Time 6.

d. Only 3 variables had no significant change from Time 2 to Time 6.

For the third hypothesis, concerning the time and sex interaction (3rd column of Tables 26, 27, 28 it was found that all of the variables, except the following two, showed no time and sex interaction ($P< 0.05$):

1. NS-GoGn ($p = 0.0043$), 2. NP-AB ($p = 0.0215$).

In order to briefly categorize the entire statistical results from both parts of the study Tables 29, 30, 31 are providing a brief review of the variables that indicate statistical significant differences. These variables are marked with an asterisk.

TABLE 2

VARIABLE
Na-ANS

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	57,45		2,762	56,96		4,236
FEMALE	51,69		2,804	51,40		2,979
TIME 1	52,46	+0,37	3,842	53,23	+0,42	4,537
TIME 2	52,83	+0,25	3,691	53,65	+0,23	4,427
TIME 4	53,08	+0,11	3,525	53,86		4,436
TIME 6	53,19		3,691			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	57,10	+0,30	3,417	56,67	+0,33	4,396	51,24	+0,39	2,950	51,02	+0,48	3,032
T2	57,40	+0,20	2,945	57,00	+0,22	2,222	51,63	+0,26	2,857	51,50	+0,20	3,028
T4	57,60	+0,10	2,679	57,22		4,316	51,89	+0,11	2,670	51,70		2,945
T6	57,70		2,907				52,00		2,896			

TABLE 3

VARIABLE
ANS-Me

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	66,08		5,027	68,69		5,847
FEMALE	66,30		5,351	65,73		4,927
TIME 1	65,08	+1,27	5,278	66,02	+1,09	5,315
TIME 2	66,35	+0,15	5,360	67,11	+0,42	5,531
TIME 4	66,50	+0,56	5,304	67,53		5,599
TIME 6	67,06		5,232			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	65,40	+0,70	5,017	67,81	+1,0	5,539	65,00	+1,42	5,475	64,88	+1,14	4,927
T2	66,10	+0,20	5,878	68,81	+0,63	6,049	66,42	+0,13	5,386	66,02	+0,28	4,979
T4	66,30	+0,20	5,518	69,44		6,155	66,55	+0,66	5,400	66,30		4,939
T6	66,50		5,385				67,21		5,332			

TABLE 4

VARIABLE
Na-Me

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	121,3		7,356	124,1		7,935
FEMALE	117,1		6,191	116,1		5,692
TIME 1	116,5	+1,4	6,755	118,0	+1,5	7,537
TIME 2	117,9	+0,7	6,768	119,5	+0,7	7,734
TIME 4	118,6	+0,5	6,425	120,2		7,774
TIME 6	119,1		6,709			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	120,0	+1,3	7,778	122,8	+2,3	7,684	115,5	+1,5	6,361	114,9	+1,5	5,726
T2	121,3	+0,4	8,228	125,1	+1,2	8,299	117,0	+0,8	6,278	116,4	+0,7	5,763
T4	121,7	+0,6	7,775	126,3		8,002	117,8	+0,4	5,996	117,1		5,581
T6	122,3		8,051				118,2		6,279			

TABLE 5

VARIABLE
Ar-Go

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	51,00		4,395	50,50		4,592
FEMALE	44,78		3,003	44,69		3,483
TIME 1	44,65	+1,2	3,938	45,49	+1,72	4,382
TIME 2	45,77	+0,86	4,217	47,21	+0,99	4,930
TIME 4	46,63	+0,64	4,163	48,20		4,951
TIME 6	47,27		4,160			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	48,70	+1,90	4,631	48,53	+2,44	4,049	43,58	0,92	3,047	43,54	1,25	3,402
T2	50,60	+1,10	4,602	50,97	+2,03	4,510	44,50	0,79	3,136	44,79	0,96	3,489
T4	51,70	+1,30	4,738	52,00		4,719	45,29	0,47	2,850	45,75		3,315
T6	53,00		3,775				45,76		2,725			

TABLE 6

VARIABLE
S-Gn

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	127,2		8,386	130,4		9,304
FEMALE	122,0		4,337	121,6		3,978
TIME 1	121,3	+1,7	5,882	123,6	+1,8	7,658
TIME 2	123,0	+0,7	5,684	125,4	+0,5	7,857
TIME 4	123,7	+0,6	5,657	126,1		8,015
TIME 6	124,3		5,810			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	125,2	+2,0	8,857	128,7	+2,2	9,048	120,3	+1,6	4,640	120,4	+1,5	4,218
T2	127,2	+0,5	9,183	130,9	+0,7	9,434	121,9	+0,8	4,058	121,9	+0,6	3,732
T4	127,7	+1,0	9,149	131,6		9,707	122,7	+0,5	4,093	122,5		3,783
T6	128,7		8,913				123,2		4,327			

TABLE 7

VARIABLE
Ar-Gn

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	113,1		8,177	115,8		7,794
FEMALE	108,2		4,196	107,8		4,203
TIME 1	107,6	+1,2	5,904	109,5	+1,6	6,816
TIME 2	108,8	+1,1	5,352	111,1	+1,1	7,011
TIME 4	109,9	+0,5	5,405	112,2		7,132
TIME 6	110,4		5,630			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	110,9	+1,9	8,898	113,9	+2,2	7,449	106,7	+1,1	4,805	106,7	+1,1	4,666
T2	112,8	+1,0	8,490	116,1	+1,2	7,840	107,8	+1,1	3,881	107,8	+1,1	3,906
T4	113,8	+1,1	9,032	117,3		8,126	108,9	+0,4	3,729	108,9		3,844
T6	114,9		8,598				109,3		4,134			

TABLE 8

VARIABLE
Ba-Na

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	108,5		6,400	109,7		5,774
FEMALE	103,6		3,497	103,2		3,499
TIME 1	104,1	+0,6	4,964	105,3	+0,6	5,642
TIME 2	104,7	+0	4,883	105,9	+0,1	5,608
TIME 4	104,7	+0,1	4,580	106,0		5,431
TIME 6	104,8		4,537			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	108,0	+0,4	7,150	109,3	+0,5	5,993	103,1	+0,7	3,840	102,8	+0,6	3,697
T2	108,4	+0,3	7,309	109,8	+0,3	5,933	103,8	-0,1	3,724	103,4	+0	3,651
T4	108,7	+0,1	6,907	110,1		5,695	103,6		3,248			
T6	108,8		6,467				103,8		3,380			

TABLE 9

VARIABLE
PNS-ANS

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	59,35		4,710	59,28		3,581
FEMALE	53,72		2,774	54,05		2,702
TIME 1	54,44	+0,29	4,017	55,58	+0,62	3,928
TIME 2	54,73	+1,33	3,920	56,20	+0,31	4,026
TIME 4	55,06	+0,29	3,938	56,51		4,056
TIME 6	55,35		4,208			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	58,80	0	5,215	58,58	+0,75	3,639	53,29	+0,37	2,810	53,64	+0,54	2,735
T2	58,80	+0,90	5,203	59,33	+059	3,734	53,66	+0,18	2,794	54,18	+0,14	2,729
T4	59,70	+0,40	4,577	59,92		3,444	53,84	+1,87	2,759	54,32		2,692
T6	60,10		5,343				54,11		2,894			

TABLE 10

VARIABLE
Go-Gn

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	78,55		4,343	79,94		6,505
FEMALE	76,22		3,742	75,05		3,691
TIME 1	74,69	+1,27	4,258	76,26	+0,85	5,565
TIME 2	75,96	+0,50	3,975	77,11	+0,42	5,483
TIME 4	76,46	+0,08	4,059	77,53		5,527
TIME 6	76,54		4,024			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	77,60	+0,90	5,213	79,47	+0,45	6,482	73,92	+1,37	3,761	74,20	+1,10	3,723
T2	78,50	+0,40	4,987	79,92	+0,52	6,761	75,29	+0,53	3,521	75,30	+0,36	3,563
T4	78,90	+0,30	4,263	80,44		6,611	75,82	+0,02	3,863	75,66		3,757
T6	79,20		4,192				75,84		3,782			

TABLE 11

VARIABLE
S-N

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	73,63		3,539	74,09		3,906
FEMALE	71,84		11,98	70,32		10,02
TIME 1	71,58	+0,65	10,86	74,56	+0,72	8,282
TIME 2	72,23	+0,19	10,95	74,28	+0,16	8,411
TIME 4	72,42	+0,18	10,95	74,44		8,448
TIME 6	72,60		11,04			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	73,10	+0,60	4,022	70,41	+0,50	3,807	71,18	+0,66	12,09	69,40	+0,58	10,06
T2	73,70	+0,10	3,931	70,91	+0,23	3,938	71,18	+0,66	12,21	69,98	+0,27	10,18
T4	73,80	+0,10	3,616	71,14		4,133	72,05	+0,21	12,23	70,25		10,19
T6	72,26											

TABLE 12

VARIABLE
Go-Go

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	104,6		5,635	103,0		6,928
FEMALE	96,66		4,247	95,57		4,183
TIME 1	97,08	+1,19	5,399	97,55	+1,11	6,288
TIME 2	98,27	+0,67	5,678	98,66	+0,61	6,547
TIME 4	98,94	+0,02	5,726	99,27		6,758
TIME 6	98,96		5,645			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	103,3	+1,2	5,922	101,9	+1,3	6,876	95,45	+1,18	3,986	94,77	+0,98	3,943
T2	104,5	+1,0	6,185	103,2	+0,9	6,948	96,63	+0,58	4,368	95,75	+0,45	4,309
T4	105,5	-0,4	6,114	104,1		7,182	97,21	+0,13	4,299	96,20		4,310
T6	105,1		6,056				97,34		4,397			

TABLE 13

VARIABLE
Zy-Zy

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	137,5		4,574	137,8		6,914
FEMALE	129,5		5,204	129		4,608
TIME 1	129,7	+1,4	5,579	131,3	+1,4	6,728
TIME 2	131,1	+0,8	6,014	132,7	+0,6	7,152
TIME 4	131,9	+1,2	6,258	133,3		7,281
TIME 6	132,1		6,258			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	135,3	+2,0	4,618	136,3	+1,8	6,741	128,3	+1,1	4,914	128,1	+1,1	4,470
T2	137,3	+1,4	4,738	138,1	+0,9	7,027	129,4	+0,7	5,260	129,2	+0,5	4,673
T4	138,7	0	4,970	139,0		7,085	130,1	+0,3	5,302	129,7		4,701
T6	138,7		4,604				130,4		5,491			

TABLE 14

VARIABLE
SNA

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	81,60		2,088	81,57		3,607
FEMALE	79,60		2,854	80,09		2,838
TIME 1	79,98	+0,08	2,917	80,63	+0,04	3,375
TIME 2	80,06	-0,1	2,950	80,67	+0,04	3,244
TIME 4	79,96	+0,1	2,714	80,71		3,142
TIME 6	80,06		2,887			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	81,70	-0,20	1,924	81,56	0	3,753	79,53	+0,15	3,002	80,04	+0,07	3,030
T2	81,50	-0,10	2,318	81,56	+0,05	3,601	79,68	-0,10	3,033	80,11	+0,02	2,920
T4	81,40	+0,40	2,408	81,61		3,676	79,58	+0,03	2,720	80,13		2,655
T6	81,80		2,387				79,61		2,885			

TABLE 15

VARIABLE
SNB

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	77,40		2,654	78,44		3,483
FEMALE	77,64		2,630	78,13		2,705
TIME 1	77,44	+0,19	2,651	78,13	+0,21	3,067
TIME 2	77,63	+0,07	2,584	78,34	-0,06	3,007
TIME 4	77,56	+0,19	2,663	78,28		3,063
TIME 6	77,75		2,750			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	77,20	0	2,588	78,28	+0,25	3,469	77,50	+0,24	2,734	78,04	+0,17	2,841
T2	77,20	+0,10	2,885	78,53	0	3,500	77,74	-0,13	2,573	78,21	-0,08	2,706
T4	77,40	+0,40	2,987	78,53		3,672	77,61	+0,13	2,659	78,13		2,662
T6	77,80		3,033				77,74		2,761			

TABLE 16

VARIABLE
ANB

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	4,200		0,2417	3,167		2,230
FEMALE	1,954		1,693	1,964		1,888
TIME 1	2,543	-0,104	1,687	2,522	-0,163	2,145
TIME 2	2,438	-0,042	1,958	2,359	+0,065	2,240
TIME 4	2,396	-0,083	1,847	2,424		1,963
TIME 6	2,313		1,916			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	4,500	-0,200	0,500	3,333	-0,25	2,473	2,026	-0,079	1,419	2,000	-0,107	1,759
T2	4,300	-0,300	0,5385	3,083	0	2,334	1,947	0	1,833	1,893	+0,107	2,088
T4	4,000	0	0,4743	3,083		1,972	1,974	-0,106	1,791	2,000		1,871
T6	4,000		0,5477				1,868		1,832			

TABLE 17

VARIABLE
N-A-P

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	5,175		2,561	3,519		5,508
FEMALE	0,6974		4,539	0,1786		4,925
TIME 1	2,208	-0,666	4,,597	1,913	-0,565	5,450
TIME 2	1,542	-0,250	4,870	1,348	-0,152	5,571
TIME 4	1,292	-0,187	4,499	1,196		5,252
TIME 6	1,479		4,562			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	6,600	-1,300	1,949	4,000	-0,583	5,869	1,053	-0,5004	4,403	0,5714	-0,3928	4,801
T2	5,300	-0,700	2,683	3,417	-0,278	5,523	0,5526	-0,1315	4,873	0,1786	+0,3571	5,275
T4	4,600	-0,400	2,608	3,139		5,406	0,4211	+0,3421	4,528	0,5357		4,841
T6	4,200		3,033				0,7632		4,686			

TABLE 18

VARIABLE
NP-AB

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	-8,675		3,412	-6,324		4,480
FEMALE	-3,678		2,886	-3,827		3,353
TIME 1	-4,854	+0,062	3,766	-4,924	+0,174	4,076
TIME 2	-4,792	+0,188	3,730	-4,750	+0,011	4,105
TIME 4	4,604	0,021	3,624	-4,739		3,930
TIME 6	4,625		3,564			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	-9,600	+0,600	3,305	-6,611	+0,444	4,616	-3,605	-0,079	2,792	-3,839	0	3,339
T2	-9,000	+1,000	3,446	-6,167	-0,027	4,595	-3,684	-0,027	2,987	-3,839	+0,035	3,549
T4	-3,711	0	3,119				-3,804		3,290			
T6	-3,711		2,874									

TABLE 19

VARIABLE
NS-Go-Gn

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	27,98		2,578	30,20		4,080
FEMALE	33,05		4,810	32,18		4,550
TIME 1	32,48	-0,44	4,328	31,85	-0,61	4,155
TIME 2	32,04	-0,23	4,991	31,24	-0,10	4,684
TIME 4	31,81	-0,16	5,075	31,14		4,599
TIME 6	31,65		5,374			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	29,80	-1,60	2,280	31,11	-1,44	3,845	33,18	-0,13	4,501	32,32	-0,07	4,344
T2	28,20	-0,70	2,775	29,67	+0,16	4,301	33,05	-0,10	4,994	32,25	-0,27	4,713
T4	27,50	-1,10	2,179	29,83		4,159	32,95	+0,08	5,033	31,98		4,742
T6	26,40		2,510				33,03		5,084			

TABLE 20

VARIABLE
1 -Ba.Na

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	80,47		6,644	82,82		8,827
FEMALE	8,630		5,619	85,43		5,826
TIME 1	84,15	+1,04	6,537	83,64	+1,07	7,486
TIME 2	85,19	-0,06	6,382	84,71	+0,18	7,170
TIME 4	85,13	+0,75	6,407	84,89		7,140
TIME 6	85,88		6,055			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	78,50	+1,50	5,568	81,69	+1,62	9,028	85,63	+0,92	6,043	84,89	+0,72	6,159
T2	80,00	+0,90	6,490	83,31	+0,16	9,003	86,55	-0,31	5,766	85,61	+0,19	5,700
T4	80,90	+1,60	7,749	83,47		8,849						
T6	82,50		8,124				86,76		5,308			

TABLE 21

VARIABLE
1-IMPA

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	99,28		7,769	93,81		7,134
FEMALE	93,61		5,667	93,63		5,412
TIME 1	94,79	-0,04	6,229	93,35	+0,27	5,979
TIME 2	94,75	+0,08	6,439	93,62	+0,52	6,287
TIME 4	94,83	-0,04	6,803	94,14		6,196
TIME 6	94,79		7,079			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	100,1	-0,80	7,249	93,81	+0,25	6,943	93,39	+0,16	5,293	93,05	+0,29	5,384
T2	99,30	0	8,657	94,06	-0,48	7,446	93,55	+0,11	5,390	93,34	+1,16	5,546
T4	99,30	-0,90	8,628	93,58		7,411	93,66	+0,18	5,965	94,50		5,392
T6	98,40		9,106				93,84		6,405			

TABLE 22

VARIABLE
1-1

	MEAN	INCREMENT	S.D.	MEAN	INCREMENT	S.D.
MALE	133,8		6,029	133,3		10,39
FEMALE	127,9		9,750	129,3		9,002
TIME 1	129,1	+0,2	8,853	131,0	-0,4	9,685
TIME 2	128,9	+0,7	9,538	130,6	+0,3	9,850
TIME 4	129,6	-0,8	9,816	130,9		9,882
TIME 6	128,8		9,897			

	MALE						FEMALE					
	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.	MEAN	INC.	S.D.
T1	132,9	+1,2	6,025	133,1	-0,2	10,71	128,1	-0,6	9,326	129,7	-0,5	8,902
T2	134,1	0	6,427	132,9	+1	10,62	127,5	+0,9	9,878	129,2	-0,2	9,216
T4	134,1	0	7,057	133,9		10,42	128,4	-0,9	10,24	129,0		9,204
T6	134,1		6,633				127,5		10,30			

TABLE 23

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
	df=1	df=2,43	df=2,43	df=1,44	df=1,44	df=1,44	df=1,44
NA-ANS	F=26.96 P=0.0005	T^2=30.8035 F1=15.05 P=0.0000	T^2=0.4445 F1=0.22 P=0.8057	F=12.96 P=0.0008	F1=0.43 P=0.5147	F1=6.13 P=0.0172	F=0.02 P=0.8994
ANS-Me	F=3.38 P=0.0726	T^2=92.355 F1=45.13 P=0.0000	T^2=1,69149 F1=0.83 P=0.4444	F1=67.23 P=0.00000	F=0.30 P=0.5874	F1=10.96 P=0.0019	F1=1.60 P=.2128
Na-Me	F1=15.49 P=0.0003	T^2=116.162 F1=56.76 P=0.0000	T^2=0.32056 F1=0.16 P=0.8545	F=93.67 P=0.000	F1=0.10 P=0.7507	F1=25.58 P=0.0000	F1=0.23 P=0.6334
Ar-Go	F1=26.86 P=0.0000	T^2=92.5669 F1=45.23 P=0.0000	T^2=5.70999 F1=2.79 P=0.0726	F1=51.53 P=0.0000	F1=5.39 P=0.0250	F1=25.78 P=0.0000	F1=0.03 P=0.8722
S-Gn	F1=19.74 P=0.0001	T^2=155.378 F1=75.92 P=0.0000	T^2=4.29248 F1=2.10 P=0.1352	F1=146.46 P=0.0000	F1=4.28 P=0.0449	F1=25.92 P=0.0000	F1=0.07 P=0.7900
Ar-Gn	F1=20.74 P=0.0000	T^2=96.3786 F1=47.09 P=0.0000	T^2=5.78767 F1=2.83 P=0.0702	F1=47.54 P=0.0000	F1=5.46 P=0.0241	F1=32.82 P=0.0000	F1=0.03 P=0.8620
Ba-Na	F1=22.95 P=0.0000	T^2=7.89647 F1=3.86 P=0.0288	T^2=1.04955 F1=0.51 P=0.6024	F1=6.79 P=0.0125	F1=0.001 P=0.9459	F1=1.04 P=0.3127	F1=1.04 P=0.31217

TABLE 24

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
PNS-ANS	F1=32.34 P=0.0000	T^2=38.9292 F1=19.02 P=0.0000	T^2=6.0525 F1=2.96 P= 0.0626	F1=17.67 P=0.0001	F1=0.49 P=0.4872	F1=12.37 P=0.001	F1=4.55 P=0.0385
Go-Gn	F1=10.58 P=0.0022	T^2=31.0312 F1=15.16 P=0.0000	T^2=3.9965 F1=1.95 P=0.1543	F1=18.99 P=0.0001	F1=3.46 P=0.0694	F1=12.73 P=0.0009	F1=0.47 P=0.4951
S-N	F1=1.70 P=0.1991	T^2=31.5051 F1=15.39 P=0.0000	T^2=1.30053 F1=0.64 P=0.5346	F1=27.58 P=0.0000	F1=0.91 P=0.3449	F1=7.87 P=0.0075	F1=0.21 P=0.6473
Go-Go	F1=20.78 P=0.0000	T^2=115.721 F1=56.55 P=0.0000	T^2=17.34588 F1=3.59 P=0.0362	F1=69.48 P=0.0000	F1=1.39 P=0.2450	F1=68.27 P=0.0000	F1=6.87 P=0.0120
Zy-Zy	F1=26.81 P=0.0000	T^2=118.847 F1=58.07 P=0.0000	T^2=7.9042 F1=3.86 P=0.0287	F1=89.62 P=0.0000	F1=6.50 P=0.0144	F1=54.19 P=0.0000	F1=2.95 P=0.0927
SNA	F1=2.42 P=0.1273	T^2=0.254817 F1=0.12 P=0.8832	T^2=0.05925 F1=0.03 P=0.9715	F1=0.06 P=0.8128	F1=0.06 P=0.8128	F1=0.09 P=0.7706	F1=0.02 P=0.8809
SNB	F1=0.12 P=0.7296	T^2=2.32544 F1=1.14 P=0.3305	T^2=0.497713 F1=0.24 P=0.7854	F1=2.29 P=0.1377	F1=0.06 P=0.8022	F1=0.23 P=0.6320	F1=0.23 P=0.6320

TABLE 25

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
ANB	F1=3.93 P=0.0536	T^2=3.6747 F1=1.80 P=0.11783	T^2=0.9357 F1=0.46 P=0.6361	F1=3.66 P=0.0623	F1=0.59 P=0.4482	F1=0.20 P=0.6540	F1=0.20 P=0.6540
N.A.P.	F1=4.57 P=0.0381	T^2=11.8478 F1=5.79 P=0.0059	T^2=0.4274 F1=0.21 P=0.8123	F1=7.76 P=0.0078	F1=0.01 P=09422	F1=1.00 P=0.3235	F1=0.35 P=0.5582
NP-AB	F1=4.66 P=0.0363	T^2=2.19015 F1=1.07 P=0.03519	T^2=1.9503 F=0.95 P=0.3936	F1=1.77 P=0.1908	F1=1.77 P=0.1908	F1=0.001 P=09823	F=0.03 P=0.8594
NS-Go.Gn	F1=2.3 P=0.1366	T^2=18.3765 F1=8.98 P=0.0006	T^2=9.31709 F1=4.58 P=0.0157	F1=9.25 P=0.0040	F1=7.59 P=0.0085	F1=0.04 P=0.8426	F=0.74 P=0.3957
Ba-Na	F1=1.47 P=0.2312	T^2=15.7193 F1=7.68 P=0.0014	T^2=1.9057 F1=0.93 P=0.4019	F1=11.00 P=0.0018	F1=1.64 P=0.2076	F1=0.39 P=0.5208	F1=0.001 P=0.9596
T-Mpl	F1=0.01 P=0.9184	T^2=1.21053 F1=0.59 P=0.55579	T^2=2.55 F1=1.25 P=0.2978	F1=0.49 P=0.4861	F1=0.001 P=0.9629	F1=0.42 P=0.5208	F=2.36 P=0.1318
Inter	F1=1.98 P=0.1668	T^2=0.84035 F1=0.41 P=0.6658	T^2=2.1409 F1=1.05 P=0.3601	F1=0.45 P=0.5072	F1=0.09 P=0.7700	F1=0.74 P=0.3942	F1=1.32 P=0.2572

TABLE 26

ADULT

TIME 1 _____ TIME 2 _____ TIME 4_____ TIME 6
2 yrs. 2 yrs. 2 yrs.

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
	df=1,22	df=3.20	df=3.20	df=1.22	df=1.22	df=1.22	df=1.22	df=1.22	df=1.22
Na-ANS	F1=16.31 P=0.0005	T^2=13.1512 F1=3.99 P=0.0224	T^2=0.195977 F1=0.06 P=0.9805	F1=3.34 P=0.0813 by sex F1=0.06 P=0.8055	F1=7.06 P=0.0144 by sex F1=0.13 P=0.17205	F1=13.07 P=0.0015 by sex F1=0.19 P=0.6695	F1=1.78 P=0.1956 by sex F1=0.03 P=0.8572	F1=3.06 P=0.0943 by sex F1=0.03 P=0.8596	F1=0.39 P=0.5405 by sex F1=0.001 P=0.9874
ANS-Me	F=0.01 P=0.9356	T^2=48.7582 F1=14.78 P=0.0000	T^2=6.16037 F1=1.87 P=0.1678	F1=25.39 P=0.0000 by sex F1=2.93 P=0.1008	F1=20.42 P=0.0002 by sex F1=1.45 P=0.2419	F1=44.69 P=0.0000 by sex F1=5.03 P=0.0353	F1=0.43 P=0.5184 by sex F1=0.02 P=0.8935	F1=7.31 P=0.0130 by sex F1=0.78 P=0.3856	F1=5.92 P=0.0236 by sex F1=1.69 P=0.2075
Na-Me	F1=1.63 P=0.2153	T^2=45.1910 F1=13.69 P=0.0000	T^2=0.87875 F1=0.27 P=0.8487	F1=28.46 P=0.0000 by sex F1=0.11 P=0.7415	F1=31.10 P=0.0000 by sex F1=0.63 P=0.4366	F=42.5 P=0.0000 by sex F1=0.25 P=0.6203	F1=6.71 P=0.0167 by sex F1=0.72 P=0.4052	F1=14.11 P=0.0011 by sex F1=0.13 P=0.7239	F1=5.56 P=0.00177 by sex F1=0.117 P=0.6834
Ar-Go	F1=15.79 P=0.0006	T^2=43.1901 F1=13.09 P=0.0001	T^2=4.40178 F1=1.33 P=0.2914	F1=12.41 P=0.0019 by sex F1=1.49 P=0.2344	F1=34.72 P=0.0000 by sex F1=2.60 P=0.1210	F1=40.28 P=0.0000 by sex F1=4.29 P=0.0503	F1=9.46 P=0.0055 by sex F1=0.26 P=0.6182	F1=14.45 P=0.0010 by sex F1=1.39 P=0.2508	F1=7.11 P=0.0141 by sex F1=1.54 P=0.2273
S-Gn	F1=3.61 P=0.0706	T^2=81.2238 F1=24.61 P=0.0000	T^2=3.08406 F1=0.93 P=0.4424	F1=45.18 P=0.0000 by sex F1=0.46 P=0.5024	F1=49.94 P=0.0000 by sex F1=0.03 P=0.8643	F1=71.45 P=0.0000 by sex F1=0.77 P=0.3901	F1=7.33 P=0.0129 by sex F1=0.27 P=0.6094	F1=30.24 P=0.0000 by sex F1=0.34 P=0.5063	F1=17.61 P=0.0004 by sex F1=2.25 P=0.1481
Ar-Gn	F1=3.58 P=0.0716	T^2=40.6706 F1=12.32 P=0.0001	T^2=2.1374 F1=0.65 P=0.5935	F1=10.61 P=0.0036 by sex F1=0.81	F1=30.09 P=0.0000 by sex F1=0.60	F1=36.86 P=0.0000 by sex F1=1.80	F1=10.21 P=0.0042 by sex F1=0.03	F1=13.57 P=0.0013 by sex F1=0.42	F1=3.82 P=0.0634 by sex F1=0.95
Ba-Na	F1=5.18 P=0.0329	T^2=2.9056 F1=0.88	T^2=0.778687 F1=0.24	F1=2.24 P=0.1483 by sex F1=0.18 P=0.6794	F1=2.38 P=0.1483 by sex F1=0.02 P=0.8853	F1=2.72 P=0.1374 by sex F1=0.01 P=0.9230	F1=0.11 P=0.1131 by sex F1=0.70 P=0.4123	F1=0.53 P=0.7474 by sex F1=0.53 P=0.4735	F1=1.13 P=0.2986 by sex F1=0.02 P=0.8859

TABLE 27

ADULT

TIME 1 _____ TIME 2 _____ TIME 4 _____ TIME 6

2 yrs. 2 yrs. 2 yrs.

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
PNS-ANS	F1=11.50 P=0.0026	T^2=20.7349 F1=6.28 P=0.0035	T^2=6.5723 F1=1.99 P=0.1477	F1=0.88 P=0.3582 by sex F1=0.88 P=0.3582	F1=8.30 P=0.0089 by sex F1=0.47 P=0.4981	F1=15.05 P=0.0008 by sex F1=0.79 P=0.3843	F1=11.63 P=0.0025 by sex F1=5.07 P=0.0347	F1=13.46 P=0.0013 by sex F1=3.21 P=0.0871	F1=2.08 P=0.1630 by sex F1=0.09 P=0.7686
GoGn	F1=2.95 P=0.0997	T^2=19.6418 F=5.95 P=0.0045	T^2=2.73158 F1=0.83 P=0.4941	F1=13.74 P=0.0012 by sex F1=0.59 P=04522	F1=16.28 P=0.0006 by sex F1=0.56 P=0.4605	F1=19.17 P=0.0002 by sex F1=0.16 P=0.6936	F1=4.05 P=0.0565 by sex F1=0.08 P=0.7862	F1=8.41 P=0.0083 by sex F1=0.12 P=0.7362	F1=2.30 P=0.1469 by sex F1=1.62 P=0.2170
S-N	F1=0.10 P=0.7527	T^2=10.7357 F1=3.25 P=0.0433	T^2=0.65107 F1=0.20 P=0.8970	F1=7.36 P=0.0127 by sex F1=0.02 P=0.9018	F1=7.87 P=0.0103 by sex F1=0.09 P=0.7661	F1=9.94 P=0.0046 by sex F1=0.22 P=0.6444	F1=1.73 P=0.2021 by sex F1=0.22 P=0.6444	F1=4.52 P=0.0450 by sex F1=0.57 P=0.4573	F1=3.56 P=0.0724 by sex F1=0.45 P=0.5088
Go-Go	F1=11.71 P=0.0024	T^2=77.5036 F1=23.49 P=0.0000	T^2=P.3462 F1=20.83 P=0.0644	F1=22.6 P=0.0001 by sex F1=0.00 P=0.9752	F1=48.88 P=0.0000 by sex F1=0.59 P=0.4491	F1=35.39 P=0.0000 by sex F1=0.02 P=0.8802	F1=59.78 P=0.0000 by sex F1=4.25 P=0.0512	F1=52.33 P=o.0000 by sex F1=0.37 P=0.5480	F1=2.01 P=0.1702 by sex F1=7.88 P=0.0102
Zy-Zy	F1=9.58 P=0.0053	T^2=61.3820 F1=18.60 P=0.0000	T^2=8.6839 F1=2.63 P=0.0781	F1=32.58 P=0.0000 by sex F1=2.14 P=0.1578	F1=55.37 P=0.0000 by sex F1=5.33 P=0.0300	F1=53.16 P=0.0000 by sex F1=2.8 P=0.1000	F1=38.95 P=0.0000 by sex F1=6.12 P=0.0016	F1=37.94 P=0.0000 by sex F=1.41 P=0.00401	F=1.84 P=0.1882 by sex F1=1.84 P=0.1882
SNA	F1=2.13 P=0.1585	T^2=0.941176 F=0.29 P=0.8355	T^2=0.761188 F1=0.23 P=0.8739	F1=0.0001 P=0.9475 by sex F1=0.32 P=0.5772	F1=0.26 P=0.6131 by sex F1=0.53 P=0.4723	F1=0.11 P=0.7407 by sex F1=0.0001 P=0.9689	F1=0.24 P=0.6257 by sex F1=0.000001 P=0.9900	F1=0.12 P=0.7322 by sex F1=0.35 P=0.5585	F1=0.71 P=0.4100 by sex F1=0.54 P=0.4694
SNB	F1=0.03 P=0.8564	T^2=3.79423 F1=1.15 P=0.3534	T^2=2.1108 F1=0.64 P=0.5984	F1=0.17 P=0.6812 by sex F1=0.17 P=0.6812	F1=0.45 P=0.5100 by sex F1=0.04 P=0.83172	F1=3.32 P=0.0822 by sex F1=0.62 P=0.4377	F1=0.04 P=0.8396 by sex F1=0.98 P=0.3318	F1=1.41 P=0.2474 by sex F1=1.41 P=0.2474	F1=1.44 P=0.2433 by sex F1=0.37 P=0.5511

TABLE 28

ADULT

TIME 1 _____ TIME 2 _____ TIME 4 _____ TIME 6

2 yrs. 2 yrs. 2 yrs.

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
ANB	F1=7.88 P=0.0103	T^2=2.97589 F1=0.9 P=0.4577	T^2=2.23194 F1=0.68 P=0.5767	F1=0.80 P=0.3787 by sex F1=0.15 P=0.7010	F1=2.55 P=0.1249 by sex F1=1.67 P=0.2099	F1=2.69 P=0.1154 by sex F1=0.73 P=0.4032	F1=1.08 P=0.3099 by sex F1=1.54 P=0.2283	F1=1.40 P=02493 by sex F1=0.48 P=0.4973	F1=0.22 P=0.64 by sex F1=0.22 P=0.64
N.A.P	F1=4.39 P=0.0479	T^2=14.0135 F1=4.25 P=0.0178	T^2=6.69874 F1=2.03 P=0.1421	F1=6.67 P=0.0170 by sex F1=1.32 P=0.2634	F1=13.89 P=0.0012 by sex F1=3.76 P=0.0656	F1=10.02 P=0.0045 by sex F1=6.17 P=0.0211	F1=2.03 P=0.1686 by sex F1=0.95 P=0.3411	F1=1.80 P=0.1939 by sex F1=3.9 P=0.0610	F1=0.02 P=0.8874 by sex F1=3.37 P=0.0789
NP-AB	F1=10.85 P=0.0033	T^2=10.6137 F1=3.22 P= 0.0448	T^2=13.3032 F1=4.03 P=0.0215	F1=0.77 P=0.3907 by sex F1=1.30 P=0.2661	F1=8.11 P=0.0094 by sex F1=10.56 P=0.0037	F1=5.88 P=0.0239 by sex F1=7.79 P=0.0106	F1=3.55 P=0.0727 by sex F1=3.95 P=0.0595	F1=3.51 P=0.0743 by sex F1=3.95 P=0.0596	F1=0.05 P=0.8215 by sex F1=0.05 P=0.8215
NS-Go.Gn	F1=5.04 P=0.0351	T^2=24.0899 F=7.30 P=0.0017	T^2=19.8934 F1=6.03 P=0.0043	F1=8.97 P=0.0067 by sex F1=6.45 P=0.0187	F1=15.79 P=0.0006 by sex F1=10.45 P=0.0038	F=23.85 P=0.0001 by sex F1=19.80 P=0.0002	F1=1.76 P=0.1983 by sex F1=0.96 P=0.3379	F1=8.29 P=0.0087 by sex F1=7.82 P=0.0105	F1=4.58 P=0.0437 by sex F1=6.10 P=0.0001
Ba.Na	F1=3.97 P=0.0590	T^2=14.5677 F1=4.41 P=0.0155	T^2=5.10694 F1=1.55 P=0.2332	F1=3.94 P=0.0598 by sex F1=0.23 P=0.6398	F1=6.117 P=0.0211 by sex F1=2.20 P=0.1522	F1=13.22 P=0.0015 by sex F1=4.13 P=0.0543	F1=0.30 P=0.5908 by sex F1=1.29 P=0.2683	F1=5.28 P=0.0314 by sex F=3.77 P=0.0652	F1=8.21 P=0.0090 by sex F=2.09 P=0.1620
T-Mpl	F1=3.27 P=0.0842	T^2=1.35498 F1=0.41 P=0.7471	T^2=3.6491 F1=1.11 P=0.3700	F1=0.43 P=0.5208 by sex F1=0.95 P=0.3409	F1=0.32 P=0.5789 by sex F1=1.24 P=0.2778	F1=1.22 P=0.2818 by sex F1=3.58 P=0.0718	F1=0.02 P=0.8947 by sex F=0.02 P=08947	F1=0.28 P=0.5995 by sex F=1.08 P=0.3106	F=0.58 P=0.4555 by sex F=1.32 P=0.2622
Inter	F=1.63 P=0.2151	T^2=2.18175 F1=0.66 P=0.5856	T^2=1.35327 F1=0.41 P=0.7475	F1=0.13 P=0.7176 by sex F1=0.98 P=0.3323	F1=1.37 P=0.2549 by sex F1=0.47 P=0.5024	F1=0.07 P=0.7914 by sex F1=0.85 P=0.3662	F1=0.33 P=).5742 by sex F1=0.33 P=0.5742	F1=0.01 P=0.9379 by sex F1=0.00001 P=0.9807	F1=0.65 P=04272 by sex F1=0.42 P=0.5223

TABLE 29

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
NA-ANS	*	*		*		*	
ANS-Me		*		*		*	
Na-Me	*	*		*		*	
Ar-Go	*	*		*	*	*	
S-Gn	*	*		*	*	*	
Ar-Gn	*	*		*	*	*	
Ba-Na	*	*		*			

TABLE 30

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
PNS-ANS	*	*		*		*	*
Go-Gn	*	*		*		*	
S-N		*		*		*	
Go-Go	*	*	*	*		*	*
Zy-Zy	*	*	*	*	*	*	
SNA							
SNB							

TABLE 31

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST2 BY SEX	T2VST4	T2VST4 BY SEX
ANB							
N.A.P.	*						
NP-AB	*						
NS-Go.Gn		*	*	*			
Ba-Na		*		*			
T-Mpl							
Inter							

TABLE 32

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
Na-ANS	*	*			*	*			
ANS-Me		*		*	*	*		*	*
Na-Me		*		*	*	*	*	*	*
Ar-Go	*	*		*	*	*		*	*
S-Gn		*		*	*	*	*	*	*
Ar-Gn		*		*	*	*	*	*	
Ba-Na	*								

TABLE 33

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
PNS-ANS	*	*			*	*	*	*	
GoGn		*		*	*	*			
S-N		*		*	*	*		*	
Go-Go	*	*		*	*	*	*	*	*
Zy-Zy	*	*		*	*	*	*	*	
					*		*	*	
SNA									
SNB									

TABLE 34

VARIABLE	SEX	TIME	TIME BY SEX	T1VST2	T1VST4	T1VST6	T2VST4	T2VST6	T4VST6
ANB	*								
N.A.P.	*	*		*	*	*			
NP-AB	*	*	*		*	*			
					*	*			
NS-Go.Gn	*	*	*	*	*	*		*	*
				*	*	*		*	*
Ba.Na		*			*	*		*	*
T-Mpl									
Inter									

DISCUSSION

Skeletal age assessment, in this study, primarily involved the evaluation of the carpal, metacarpal and phalanges of the hand and wrist. This evaluation included examination of the number of centers of ossification present, the degree of calcification, and the degree of epiphyseal union.

In the present study the hand-wrist radiographic film was examined as the determining factor for the status of skeletal maturity. The purpose of this study was to evaluate its validity. Also increments of growth were compared two years before and subsequently two and four years after adulthood was reached in order to find if there is a clinically significant change over time for the male and female samples, which could help the clinician in manipulative treatment. In a part of the study, also, an objective was to identify any possible time and sex interaction or correlation that might exist within the sample population.

The sample consisted of 21 males and 34 females from the files of Bolton-Brush study at Case Western Reserve University, Cleveland, Ohio. The subjects were all Caucasian, Cl I skeletal and dental, never treated orthodontically. Records were obtained every three

months for the first postnatal year, after which the examination was taking place every six months, from the age of 12 months until the age of 6 years, and subsequently every year.

Twenty-one measurements (horizontal, vertical, oblique, angular and frontal) were assessed from lateral and frontal cephalometric radiographs for an interval of two years before and after the skeletal adulthood was reached. However, we included in the records measurements of two year intervals after the skeletal maturity was reached, going as far as the individual records were permitting for each patient, increasing this way the statistical and clinical significance of the results.

The skeletal adulthood for each individual case was assessed from the hand-wrist radiographs, by the inspectional method, with the help of the Pyle-Waterhouse-Greulich Atlas of Radiographic Standard of Reference.

For this sample the mean adulthood age for males was 17 years and 9 months, with a range from 15 years to 20 years (chronological age).

For the female sample, the mean age was 16 years and 6 months and the range was from 13 years and 2 months to 20 years of chronological age.

Three principal questions were asked in this study:

1. Is there a sex difference between the males and the females in this sample? 2. Is there a change over time? 3. Is there any time and sex interaction, between males and females?

Answering the 1st question, it was found that there is a clinical significant sex difference between males and females for 2 vertical measurements (1) Ar-Go and 2. Na-ANS), one horizontal measurement (PNS-ANS), one oblique measurement (Ba-Na), both of the frontal measurements (1. Go-Go and 2. Zy-Zy), and two angular measurements (1. NP-AB and 2. N-A-P).

For the above measurements bigger increments were found for males than females. In the vertical dimension Ar-Go (ramal height) seemed to grow more than the upper anterior facial height (Na-ANS), in males than females.

Although, we know that the volume of bone produced at the condyle is not great, the amount is critical in terms of overall coordination of maxillomandibular growth.

This larger increment of growth of Ar-Go relatiev to the smaller increment of upper anterior facial height (Na-ANS) in males reconfirms Behrents (1985) finding with regard to mandibular plane rotation in a forward direction.

As Bjork (1951, 1963, 1966) reported, the condylar contribution to growth in the adult is felt to terminate

later than that for the face in general, but not later than approximately 22 years of age. However little change in overall morphology can occur after the time of maturation, verifying the possibility of condylar growth and remodeling after the adulthood is reached. (Keen, 1945).

A larger increment in males was observed for the palatal length (PNS-ANS), which suggests an advantage for the clinician correcting anteroposterior discrepancies of the upper arch skeletal and especially dental cranial base length (Ba-Na), although presenting larger values for the time intervals examined in this study, did not show clinical significant increments (0-0,6 mm).

Both of the frontal measurements (Go-Go and Zy-Zy), and especially the bizygomatic width, manifested larger values for the male than the female samples in this study. The relates more squared and "masculine" appearance of the posterior part of the male jaw. However, the gonial region still lies well inside (medial to) the cheekbone (25-30 mm) in both sexes.

Answering the second question, it was concluded that a statistically significant difference occurred over time for the vertical, horizontal, oblique and frontal measurements, as well as for 3 out of the 9 angular measurements (N-A-P, NS-Go.Gn, I-BaNa).

For the vertical measurements clinically significant

increments of growth were found for the time interval of 2 years before adulthood. Only for ramal height were significant increments found after adulthood was reached (especially for males). However, growth on the vertical dimension continued after the adulthood was reached in an apparently decelerating manner.

In the oblique measurements, the expression of the direction of the growth of the face (S-Gn) and the mandibular length (Ar-Gn) manifested clinically significant growth increments before and after skeletal maturation was reached, in contrast to the length of the cranial base (Ba-Na). The latter seemed pretty stable from 2 years before adulthood to 4 years after adulthood. This growth increment observed at Gn even if not great, can help the clinician working with growth and trying to "compensate" in anteroposterior corrections of dento-alveolar and (to a lesser extent) skeletal malocclusions.

From the angular measurements, those representing the anteroposterior relationship of the maxillary and mandibular basal arches to the cranial base and to each other didn't seem to change over time. From that we can say that during the period from 2 years before skeletal maturation to 4 years after skeleturation, the maxilla and the mandible seemed to determine a fixed (relatively) position anteroposteriorly in relation to each other and

to the cranial base as well.

Severe anteroposterior skeletal corrections are presently difficult to achieve by orthodontic appliances only, and a consultation between the orthodontist and the orthognathic surgeon seems to be helpful for this.

For the dental-angular measurements showing the position of the lower incisors over the basal bone (IMPA) and the interincisal angle showing the angulation of the upper and lower incisors to each other and to the face, seemed to "occupy" a stable position over time for the time period examined in this study.

maintaining acceptable angulation of the lower incisors over the basal bone and also to the upper incisors, during and after orthodontic treatment, can provide a very stable resulot regarding the vertical and horizontal dimensions of the lower face and also the esthetics with a better and more constant profile.

Trying to answer the third question, concerning the tim sex interaction between the male and female population, it was found that except for one variable (NS-GoGn) all the other variables did not show time and sex interactions, verifying the hypothesis that the two genders follow the same pattern of change over time.

From this study it can be verified that the hand-wrist radiograph is highly reliable for the ortntist and can be used as a standard orthodontic record to

evaluate remaioning growth for a particular patient (potential for the orthodontist to work with), and to determine position in the growth curvature.

This study was different from previous reports in attemp[ting to assess skeletal maturation and its consequences in treatment planning in several regards: first, 15 Bolton faces were used in this sample (7 males and 8 females) taken from the sample utilized for the Bolton Standards of Dentofacial Developmental Growth. Second, a particular combination of 21 measurements was used which provided a comprehensive view of vertical, oblique, horizontal and angular growth changes after the skeletal maturation was reached (as well as 2 years before). Third, time intervals used in this study gave an accurate interpretation of amounts of growth prior to skeletal adulthood and in addition, two and four years subsequently.

In view of the findings of Dr. Behrents (1984), in his recall study of participants in the Bolton collection, the present study suggests that only minor changes in those facial dimensions that were examined, had taken place four years before skeletal maturity. The magnitude of these changes does not preclude the use of the Bolton standards in assessing form and balance proportions with the limitation that those are individual changes, throughout life.

As it was mentioned above, in the present study different combs of linear and angular measurements, as well as a period from two years before to two and four consecutive years after adulthood was reached, were selected to evaluate the validity of the hand-wrist radiograph in assessing the skeletal maturity. During the same period clinically significant increments of growth were found for a few of the above measurements which y could help the clinician in manipulative treatment. However, the increments of growth founf in the Bolton faces that were studied as well as the additional normal sample were not large enough to use in formulating a growth oriented orthodontic treatment plan. Still, there were changes observed and individual variations may affect results of treatment, particularly in the cases of surgical orthodontic correction.

Regarding recommendations for future studies, a limitation imposed by the present data is that only Class I individuals who received no orthodontic treatment were studied. Nevertheless, the skeletal maturity question becomes more significant when the clinician is dealing with Cl II or Cl III individuals. This study cannot generalize conclusions about Cl II and Cl III patients, and a parallel study should now be conducted to determine increments of growth for these categories.

SUMMARY AND CONCLUSIONS

In this study an effort was made, and proven that skeletal age assessment from the hand-wrist radiographic film can be highly reliable for the orthodontist. It was significant in the evaluation of skeletal maturity and can measurably help the clinician in defining the position of the individual patient in his growth curvature.

For the purpose of this study 21 males and 34 females were selected from the files of Bolton-Brush study at Case Western Reserve University, Cleveland, Ohio. The subjects were all Caucasian, Cl I skeletal and dental never treated orthodontically. Twenty-one measurements were assessed from lateral and frontal cephalometric radiographs for the following time intervals:

2 years before adulthood (T1), adulthood (T2), 2 years after adulthood and for some of them 4 years after adulthood.

A Repeated Measures Analysis was used to analyze statistically the data. From the results we concluded that there was a clinical significant sex difference between males and females for 2 vertical measurements (1. Ar-Go and 2. Na-ANS), one oblique measurement (Ba-Na) one

horizontal measurement (PNS-ANS), both frontal measurements (1. Go-Go and 2. Zy-Zy) and two angular measurements (1. NP-AB, 2. N-A-P).

Also, it was found that a clinical significant difference occurred over time for the vertical, horizontal, oblique and frontal measurements. The angular measurements 1. SNA, 2. SNB, 3. ANB, 4. IMPA and 5. Interincisal angle didn't seem to change over time.

Regarding the last question, we found that except NS-GoGn the other variables didn't show any time and sex interaction, over the time period studied, in this study, and the two genders seemed to follow a parallel growth pattern after skeletal adulthood was reached.

The growth increments found after skeletal adulthood was reached were smaller in comparison with those achieved before and only for some variables can be considered helpful for the orthodontist in his treatment mechanotherapy.

In previous studies the chronological, dental and skeletal age along with other developmental markers such as menarche, voice changes, secondary sex characteristics and height were used for the assessment of the maturational status. In this study the skeletal age assessment from the hand-wrist radiographic film was used to evaluate the maturational level of individuals, by the inspectional method and the help of the

Pyle-Whitehouse-Greulich Atlas.

As the sample of this study was consisted from only Cl I dental and skeletal individuals, another similar study could be conducted for Cl II and Cl III patients, to generalize may be our results for those categories also.

LITERATURE CITED

1. Abernathy, E.M.: Correlations in Physical and mental Growth, J. Ed. Psychol., 16:458-466, 1925.

2. Acheson, R.M., and D. Hewitt: Physical Development in the English and American Pre-School Child, A Comparison Between Findings in the Oxford and the Brush Foundation Surveys, Human Biol., 26:343-355, 1954.

3. Acheson, R.M.: A Method of Assessing Skeletal Maturity from Radiographs, J. Anat., 88:498-508, 1954.

4. Acheson, R.M.: Maturation of the Skeleton. In Faulkner, F., editor: Human Development, Philadelphia, W.B. Saunders Co., pp. 465-502, 1966.

5. Anderson, D.L., G.W. Thompson, and F. Popovich: Interrelationships of Dentgal Maturity, Skeletal Maturity, Height and Weight from Age 4 to 14 Years Growth, 39:453-462, 1975.

6. Baer, M.J.: Dimensional Changes in the Human Head and Face in the Third Decade of Life, Am. J. Phys. Anthropol. 14:557-575, 1956.

7. Baldwin, B.T., L.M. Busby, and H.V. Garside: University of Iowa Studies in Child Welfare, Anatomic Growth of Children, Iowa City, University of Iowa Press, 1928.

8. Bambha, J.K.: A Longitudinal Cephalometric Radiographic Study of Face and Cranium in Relation to Skeletal Maturation, J. Am. Dent. Assoc., 63:776-799, 1961.

9. Bambha, J.K., and P. Van Natta: A Longitudinal Study of Facial Growth in Relation to Skeletal Maturation During Adolescence, Am. J. Orthod., 49:481-493, 1963.

10. Bardeen, C.R.: The Relation of Ossification to Physiological development, J. Radiol, 2:1-8, 1921.

11. Bagley, N.: Skeletal Maturing in Adolescence as a Basis for Determining Percentage of Completed Growth, Child Development, 14:5-45, 1943.

12. Bagley, N. and S.R. Pinneau: Tables gfor Predicting Adult Height From Skeletal Age: Revised for Use with the Greulich-Pyle hand Standards, J. Ped., 40:323-441, 1952.

13. Beattie, J.R.: Serial Radiographic Cephalometric Study of Mandibular Growth and its Reationship to Height, Weight, and Skeletal Age, M.S. Thesis, Cleveland, Western Reserve University, 1963.

14. Behrents, R.G.: Growth in the Aging Craniofacial, Monograph 17-Craniofacial Growth Series, Center for Human Growth and development, The University of Michigan, Ann Arbor, Michigan, 1985.

15. Bergersen, E.O.: The Male Adolescent Facial Growth Spurt: Its Prediction and relation to Skeletal Maturation, Angle Orthod. 42:319-338, 1972.

16. Bjork, A. and S. Helm: Prediction of the Age of Maximum Pubertal Growth in Body Height, angle Orthod. 37:142-143, 1961.

17. Boocs, F.: Studies in Growth, Human Biol., 4:307-350, 1932.

18. Broadbent, B.H.: Face of the Normal Child, Angle Orthod. 7:183, 1937.

19. Broadbent, B.H., Jr., and W.H. Golden: The Value of an Assessment of Skeletal Maturity in Orthodontic Diagnosis, Am. J. Phys. Anthropol., 35:409-410, 1971.

20. Brodie, A.G.: On the Growth Pattern of the Human Head From The Third Month to the Eighth Year of Life, Am. J. Anatom., 68:209, March 1941.

21. Brodie, A.G.: Late Growth Changes in the Human Face, Angle Orth., 23:146, July 1953.

22. Buehl, C. and S.I. Pyle: The Use of Age at First Appearance of Three Ossification Centers in Determining the Skeletal Status of Children, J. Pediatr., 21:335-342, 1942.

23. Burstone, C.J.: Process of Maturation and Growth Prediction, Am. J. Orthod., 49:907-918, 1963.

24. Carter, T.M.: Technique and Devices Used in Radiographic Study, of the Wrist Bones of Children, J. Educ. Psychol., 17:237-247, 1926.

25. Cattall, P.: Preliminary Report on the Measurement of Ossification of the Hand and Wrist, Human Biol., 6:454-471, 1934.

26. Chapmoan, S.M.: Ossification of the Abductor Sesamoid and the adolescent Growth Spurt, Angle Orthod., 42:236-244, 1972.

27. Christie, A.: Prevalence and Distribution of Ossification Centers in the Newborn Infant, Amer. J. Dis. Child., 77:355-361, 1949.

28. Christie, A., M. Martin, E.L. Williams, E. Hudson and J.C. Lanier: Estimation of Fetal Maturity By Roentgen Studies of Osseous Development, Amer. J. Obstet. Gyn., 60:133-139, 1950.

29. Cobb, W.M.: Choice of an Area for Assessment, Am. J. Phys. anthrop., 35:385-386, 1971.

30. Deming, J.: Application of the Gompertz Curve to the Observed Pattern of Growth in Length of 48 Individual Boys and Girls During the Adolescent Cycle of Growth, Human Biol., 29:83-122, 1957.

31. Demish, A., and P. Wartmann: Calcification of the Mandibular Third Molar and its Relation to Skeletal and Chronological age in Children, Child Develop., 27:459-465, 1956.

32. Dolan, D.B.: A Study of the appearance, Timing, Amptitude and Duration of the Growth Spurt for Peripheral Measurements in the Three Dimensions of th Face in Girls with Normal Occlusion, Master Thesis, University of Pittsburgh, School of Dentistry.

33. Downs, W.: Variations in Facial Relationships, Angle Orthod., 19:145-155, 1949.

34. Edwards, J.: Master's Thesis. Utilizing Hand-wrist Radiographs to Compare Craniofacial Development with Longitudinal Growth of the Hand, West Virginia University, School of Dentistry, West Virginia, 1984.

35. Ellis, R.W.B.: Height and Weight in Relation to Onset of Puberty in Boys, Arch. Dis. Childhood, 21:181-189, 1946.

36. Enlow, D.H.: An Evaluation of the Use of Bone Histology in Forensic Medicine and Anthropology, In: Studies on the Anatomy and Function of Bone and Joints, F.G. Evans (ED.), New York, Springer-Verlag, 1966.

37. Enlow, D.H.: Handbook of Craniofacial Growth, 2nd Ed., W.B. Saunders Co., 1982.

38. Flecker, H.: Time of Appearance and Fusion of Ossification Centers as Observed by Roentgenographic Methods, Am. J. Roentgenal. Rad. Therapy, 47:97-159, 1942.

39. Flory, C.: Osseous Development in the Hand as an Index of Skeletal Development (Monograph), Committee on Child Development, University of Chicago Press, Chicago, 1936.

40. Foster, T.D.: A Textbook of Orthodontics, 2nd Ed., Boston, Blackwell Scientific Publications, 1982.

41. Francis, C.C.: The Appearance of Centers of Ossification From 6 to 15 Years, Am. J. Phys. Anthropol., 27:127-138, 1940.

42. Frisancho, R.A., S.M. Garn, and C.G. Rohman: Age at Menarche: a New Method of Prediction and Retrospective assessment Based on Hand X-rays, Human Biol., 41:42-50, 1969.

43. Fukuhara, T. and M. Matsumoto: A Longitudinal Study of Facial Growth in Relation to general Body Height During Adolescence, Bull, Tokyo Med. Dent. Univ. 15:161-170, 1968.

44. Garn, S.M. and Z. Shamiz: Methods for Research in Human Growth, Springfield, Il., Charles C Thomas, pg. 44, 1958.

45. Garn, S.M. and C.G. Rohman: Communalities of the Ossification Centers of the Hand Wrist, Am. J. Phys. Anthrop., 17:319-323, 1959.

46. Garn, S.M., and C.G. Rohman: Variability in the Order of Ossification of the Bony Centers of the Hand andf Wrist, Am. J. Phys. Anthrop., 18:219-230, 1960.

47. Garn, S.M., C.G. Rohmann and B. Appelbaum: Complete Epipyseal Union of the Hand, Am. J. Phys. Anthrop., 20:297-302, 1962.

48. Garn, S.M. and C.G. Rohmann: The abductor Sesamoid of the Thumb, Am. J. Phys. Anthrop., 20:297-302, 1962.

49. Garn, S.M., F.N. Silverman, and C.G. Rohmann: A Rational approach to the Assessment of Skeletal Maturation, Ann. Radiol., 7:297-307, 1964.

50. Garn, S.M., K. Hertzog, A.K. Poznanski, and J.M. Nagy: Metacarpopharalangeal Length in the Evaluation of Skeletal Malformations, Radiol., 105:372-381, 1972.

51. Gray, S., and F. Lamons: Skeletal Development and Tooth Eruption in atlanta, Amer. J. Orthod., 45:272-277, 1959.

52. Green, L.J.: The Inter-relationship Among Height, Weight, and Chronological, Dental, and Skeletal Ages, Angle Orthod., 31:189-193, 1961.

53. Greulich, W.W.; Some Observations on the Growth and Development of Adolescent Children in Symposium on adolescence, J. Ped., 19:302-314, 1941.

54. Greulich, W.W.: The Rationale of assessing the Developmental Status of Children from Roentgenograms of the Hand and Wrist, Child Develop., 21:33-44, 1950.

55. Greulich, W.W. and S.T. PyleP: Radiographic Atlas of Skeletal Development of the Hand and Wrist, 1st ed. Palo Alto, Calif., Stanford University Press, 1950.

56. Greulich, W.W. and S.I. Pyle: Radiographic Atlas of Skeletal Development of the Hand and Wrist, ed. 2, Standford, Calif., Standford Univesrity Press, 1959.

57. Gzon, A.M.: Prediction of Tooth Emergence, J. Dent. Res., 41: 573-585, 1962.

58. Hansman, C.F. and M.M. Maresch: A Longitudinal Study of Skeletal Maturation, Am. J. Dis. Child, 101:305-321, 1961.

59. Harris, E.J.: A Cephalometric analysis of Mandibular Growth Rate, Am. J. Orthod., 48:162, 1962.

60. Hagley, L.B.: Cephalometric Standards for Children 4 to 8 years of Age, Am. J. Orthod., 40:51-59, 1954.

61. Hellman, M.: Ossification of Epiphyseal Cartilages in the Hand, amer. J. Phys. Anthrop., 11:223-257, 1928.

62. Hewitt, D., and R.M. Acheson: Some Aspects of Skeletal Development Through Adolescence. II. The Inter-relationship Between Skeletal Maturation and Growth at Puberty, Am. J. Phys. Anthropol., 19:333-344, 1961.

63. Howard, C.C.: The Physiologic Progress of the Bone Centers of the Hands of Normal Children Between the ages of 5 and 16 Inclusive; also a Comparative Study of Both Retarded and Accelerated Hand Growth in Children Whose General Skeletal Growth is Similarly Affected, Int. J. Orthod., 14:948-997, 1928.

64. Howells, W.W.: a Factorial Study of Constitutional Type, Am. J. Phys. Anthrop., N.5 10:91-118, 1952.

65. Hoyte, D.A.N. and D.H. Enlow: Wolff's Law and the Problem of Muscle attachment on Resorptive Surfaces of Bone, Am. J. Phys. Anthrop, 24:205-214, 1966.

66. Hughes, B.O.: Dental Development and the Child as a Whole, Am. J. Orthod., 44:564-574, 1958.

67. Hunter, C.J.: The Correlation of Facial Growth with Body and Height and Skeletal Maturation at adolescence, Angle Orthod., 36:44-54, 1966.

68. Hunter, W.S., D.R. Balbach and P.E. Lamphinear: The Heredita-bility of attained Growth in the Human Face, am. J. Orthod., 58:128-134, 1970.

69. Johnston, F.E.: The Concept of Skeletal age, Clin. Ped., 1:133-143, 1962.

70. Johnston, F.E.: Skeletal Age and its Prediction in Philadelphia Children, Human Biol., 35:192-202, 1963.

71. Johnston, F.E., H.P. Hufhman, A.F. Moreschi, and G.P. Terry: Skeletal Maturation and Cephalofacial Development, Angle Orthod., 35:1-11, 1965.

72. Krogman, W.M.: Let's Get Our Teeth Into Problems of Growth, J. Can. Dent. Assoc., 25:417-423, 1959.

73. Krogman, W.M.: The Human Skeleton in Forensic Medicine, C.C Thomas, Springfield, III, 1962.

74. Lamons, F.F., and S.W. Gray: A Study of Relationship Between Tooth Eruption age, Skeletal Development Age, and Chronological age in Sixty-one Atlanta Children, Am. J. Orthod., 44:687-691, 1948.

75. Lauterstein, A.M.: a Cross-sectional Study in Dental Develop-ment and Skeletal Age, J. Am. Dent. Assoc., 62:161-167, 1961.

76. Linder-Aronson, S., D.G. Woodside, and D.J. Daigle: A Longi-tudinal Study on the Growth in Length of the Maxilla in Boys Between ages 6-10 Years, In press.

77. Lloyd, E.P.: Vertical Contral in Fully-banded Orthodontic Treatment, The Angle Orthod, July 1986, 51:170-180.

78. Logan, W. and R. Kronfeld: Development of the Human Jaws and Surrounding Structires from Birth to the Age of Fifteen Years, J. Am. Dent. Assoc., 20:379-342, 1933.

79. Lowell, F. and H. Woodrow: Some Data on anatomical age and Its Relation to Intelligence, Pedagog. Semin., 29:1-15, 1922.

80. Malina, R.: a Consideration of Factors Underlying the Selection of Methods in the Assessment of Skeletal Maturity, Am. J. Phys. Anthrop., 35:341-346, 1970.

81. Maj, G., and C. Luzi: Analysis of Mandibular Growth on 28 Normal Children Followed from 9 to 13 Years of Age, Trans. Europ. Orthod. Soc., 38:141-158, 1962.

82. Massler, M., I. Schour, and H.G. POnchez: Developmental Pattern of the Child as Reflected in the Calcification Pattern of the Teeth, Am. J. Diseases of Children, 62:33-67, 1941.

83. Meredith, H.V.: Serial Study in a Mandibular Dimension During Childhood and Adolescence, Growth 25:229, 242.

84. Meredith, H.V.: Childhood Interrelations of Anatomic Growth Rates, Growth, 26:23-39, 1962.

85. Moed, G., B. Wright, and H.N. Vandergrift: Studies of Physical Disability: Reliability of Measurements of Skeletal Age from Hand Films, Child Dev., 33:37-41, 1962.

86. Moore, W.M.: Comparability in Skeletal Maturation Research, Am. J. Phys. Anthrop., 35:411-416, 1955.

87. Moreschi, A.F.: Facial Growth in Relation to Chronological Age and to Skeletal Age (abs.), Am. J. Orthod., 50:630, 1964.

88. Nanda, R.S.: The Rates of Growth of Several Facial Components from Serial Cephalometric Roentgenograms, Am. J. Orthod., 41: 548-573, 1955.

89. Nelson, W.E.: Textbook of Pediatrics, 7th Ed., Philadelphia, W.B. Saunders, 1959.

90. Newman, K. and H. Meredith: Individual Growth in Skeletal Bigonial Diameter During the Childhood Period from 5 to 11 Years of Age, am. J. Anat., 99:157-187, 1956.

91. Nicholson, A.B. and C. Hanley: Indices of Physiological Maturity: Derivation and Interrelationships, Child Develop., 24:3-38, 1953.

92. Nolla, C.M.: The Development of the Permanent Teeth, J. Dent. Child., 27:254-266, 1960.

93. O'Rarilly, R. and D.B. Meyer: Roentgenographic Investigation of the Human Skeleton During Early Fetal Life, Amer. J. of Roentgenol., 76:455-468, 1956.

94. O'Rarilly, R., D.J. Gray and E. Gardner: Chondrification in the Hands and Feet of Ataged Human Embryos, Journal of Embryol., 36:183-192, 1957.

95. O'Rarilly, E., E. Gardner, and D.J. Gray: The Skeletal Development of the Hand, Clin. Orthoped., 13:42-51, 1959.

96. O'Rarilly, R., R. Gardner, and D.J. Gray: The Skeletal Development of the Foot, Clin. Orthoped., 16:7-14, 1960.

97. Pileski, R.C., D.G. Woodside, and G.A. James: Relationship of the Ulnar Sesamoid Bone and Maximum Mandibular Growth Velocity, Angle Orthod., 43:162-170, 1973.

98. Pryor, J.W.: Differences in the Time of Development of Centers of Ossification in the Male and Female Skeleton, Anat. Rec., 25:257-273, 1923.

99. Pryor, J.W.: Time of Ossification of the Bones of the Hand of the Male and Female and Union of Epiphyses with the Diaphyses, Am. J. Phys. Anthrop., 8:401-410, 1925.

100. Pryor, H.B.: Certain Physical and Physiological Aspects of Adolescent Development, J. Ped., 8:52-62, 1936.

101. Pyle, S.I. and C. Menino: Observations on Estimating Skeletal Age From the Todd and the Flory Bone Atlases, Child Develop., 10: 27-34, 1939.

102. Pyle, I., and L.W. Sontag: Variability in Onset of Ossification in Epiphysis and Short Bones of the Extremities, Am. J. Roentgenol. Rad. Therapy, 49:795-798, 1943.

103. Reynolds, E.L.: Degree of Kinship and Pattern of Ossification, Am. J. Phys. Anthrop. N.S., 1:405-416, 1943.

104. Rose, G.J.: A Quantitative Study of the Facial Areas from the Profile Roentgenograms and the Relationships to Body Measurements, Am. J. Orthod., 39:59-61 (Abstr.), 1953.

105. Rotch, T.M.: A Study of the Development of the Bones in Childhood by the Roentgen Method, With The View of Establishing a Developmental Index for the Grading of and the Protection of Early Life, Trans. Assoc. Am. Physicians, 24:603-624, 1909.

106. Salzmann, J.A.: General Growth Acceleration and Retardation in relation to Dentofacial Development, Am. J. Orthod., 40: 243-258, 1954.

107. Savara, B.S.: Growth of Mandible and Physique in Girls, Intern. Assoc. Dent. Res., 41:98 (Abstr.), 1963.

108. Schour, I., and M. Massler: The Development of the Human Dentition, J. Am. Dent. Assoc., 28:1153-1160, 1941.

109. Shelling, D.H. and G.M. Anderson: Relation of Rickets and Vitamin D to the Incidence of Caries, Enamel Hypoplasia and Malocclusion in Children, J.A.D.A., 23:840, 1936.

110. Shuttlesworth, F.K.: Sexual Maturation and the Skeletal Growth of Girls, Age Six to Nineteen, (Monograph), Soc. Res. Child Dev., 3:1-56, 1938.

111. Singh, I.J., B.S. Savara and P.A. Miller: Interrelations of Skeletal Measurements of the Face and Body in Preadolescent and Adolescent Girls, Growth, 31:119-131, 1967.

112. Simmons, K., and W.W. Greulich: Menarcheal Age and the Height, Weight, and Skeletal Age of Girls Age 7-17 Years, J. Ped., 22: 518-545, 1943.

113. Smith, R.: Misuse of Hand-wrist Radiographs, Am. J. Orthod. 77:78-81, January 1980.

114. Sontag, L.W., D. Snall and M. A. Anderson: Rate of Appearance of Ossification Centers from Birth to the Age of Five Years, Am. J. Dis. Child., 58:949-956, 1939.

115. Sontag, L.W. and J. Lifford: The Effect of Illness and Other Factors on appearance Pattern of Skeletal Epiphyses, J. Pediat., 23:391-409, 1943.

116. Sontag, L.W. and E.L. Reynolds: Ossification Sequences in Identical Tablets, J. Hered., 35:57-64, 1944.

117. Spiez, L.: Physiological Age: The Relation of Dentition to Body Growth, Dent. Cos., 60:899-905, 1918.

118. Stuart, H.C.: Observation of Growth of Children in Pediatric Practice, Am. J. Dis. Child, 57:1417-1421, 1939.

119. Stuart, H.C.: Physical Growth During Adolescence, Am. J. Dis. Child., 74:495-502, 1947.

120. Sutow, W.W., T. Terasaki, and K. Ohwaada: Comparison of Skeletal Maturation with Dental Status in Japanese Children, Pediatr., 14:327-333, 1954.

121. Tanner, J.M.: Growth at Adolescence, Springfield, Ill., Charles C Thomas, Publisher, 1955.

122. Tanner, J.M. and R.H. Whitehouse: Styandards of Skeletal Maturity, International Children's Centre, Paris, 1959.

123. Tanner, J.M., R.H. Whitehouse, and M. Healey: A New System for Estimating Skeletal Maturity from the Hand and Wrist, With Standards Derived from a Study of 2,600 Healthy British Children II. The Scoring System, International Children's Centre, Paris, 1962.

124. Todd, T.W.: The Adolescent Lag, Physical and Mental Adolescent Growth, Proc. of Conference on Adolescence, Brush Foundation, Case Western Reserve University, Cleveland, 1930.

125. Todd, T.W.: Atlas of Skeletal Maturation, I. Hand, St. Louis, The C.V. Mosby Co., 1937.

126. Todd, T.W.: The Constitution of the Normal Child, Angle Orthod., 7:131-137, 1937.

127. Tofani, M.I.: Mandibular Growth at Puberty, Am. J. Orthod., 62:176-195, 1972.

128. Tracy, W.E., and B.S. Savara: Norms of Size and Annual Increments of Five Anatomical Measures of the Mandible in Girls From 3 to 16 Years of Age, Arch. Oral Biol., 11:587-598, 1966.

129. Watson, E.H., and G.H. Lowery: Growth and Development of Children, Chicago, Year Book Publishers, 1954.

130. Woods, G.A.: Changes in Width Dimensions Between Certain Teeth and Facial Points During Human Growth, Am. J. Orthod., 36:676-700, 1950.

ADDITIONAL READING

1. Bayer, L.M. and N. Bayley: Growth Diagnosis, Chicago, University of Chicago Press, 1959.

2. Bergersen, E.O.: The Direction of Facial Growth From Infancy to Adulthood, Angle Orthod., 36:18-43, 1966.

3. Bjork, A.: The Face in Profile, Lund, Sweden, Berlingska Boktryckeriet, 1947.

4. Brown, T.: Skeletal Maturity and Facial Growth Assessment, Aust. Orthod. J. 2:80-87, 1970.

5. Burry, J.: A Preliminary Report on the Rontgen or X-rays, J.A.M.A. 26:402-404, 1896.

6. Crampton, C.W.: Anatomical or Physical Age: Versus Chronologic Age, Pediatr. Sem. 15:230-237, 1908.

7. Glasser, O.: Wilhelm Conrad Rontgen und die Geschichte der Rontgenstrahlen, Berlin, 1931, Springer Verlag.

8. Glasser, O.: Dr. W.C. Rontgen, ed. 2, Springfield, Ill., 1958, Charles C Thomas, Publisher.

9. Glasser, O.: Dr. W.C. Rontgen, ed. 2, Springfield, Ill., 1958, Charles C Thomas, Publisher.

10. Grave, K.C.: Timing of Facial Growth: A Study of Relations with Stature and Ossification in the Hand Around Puberty, Aust. Orthod. J., 5:117-121, 1973.

11. Krogman, W.M.: The Meaningful Interpretation of Growth and Growth Data by the Clinician, Am. J. Orthod. 44:411-432, 1958.

12. Krogman, W.M.: Problems of Growth and Development of Interest to the Dentist, Dent. Clin. North Am., 497-514, July, 1958.

13. Krogman, W.M.: Child Growth, Ann Arbor, Mich., The University of Michigan Press, 1972.

14. Lewis, A. and S. Garn: The Relationship Between Tooth Formation and Other Maturational Factors, Angle Orthod., 30:70-77, 1960.

15. McCammon, R.W.: Huan Growth and Development, Springfield, Ill., Charles C Thomas, Publisher, 1970.

16. Meredith, H.V. and V.B. Knott: Height-weight Interpretation Told for Boys and Girls, Prepared for the Joint Committee on Health Problems in Education of the N.E.A. and A.M.A., Iowa City, State University of Iowa, 1964.

17. Moore, A.W.: Observations on Facial Growth and Its Clinical Significance, Am. J. Orthod., 45:399-423, 1959.

18. Moorrees, C. and R. Reed: Changes in Dental Arch Dimensions Expressed on the Basis of Tooth Eruption as a Measure of Biological Age, J. Dent. Res., 44:129-141, 1965.

19. Moyers, R., and W.M. Krogman: Craniofacial Growth in Man, Elmsford, N.Y., Pergamon Press, Inc., 1971.

20. Perry, H.T.: Anticipating Adolescent Growth Vectors and Velocities, Am. J. Orthod. 62:589-590, 1972.

21. Pryor, J.W.: Development of the Bones of the Hand, Bull. State Coll. Kentucky Series 2:95, 1905.

22. Pryor, J.W.: The Chronology and Order of Ossification of the Bones of the Human Carpus, X-ray Method, Bull. State Coll. Kentucky (new series) 1:24, 1908.

23. Pyle, S.I.: Personal communication.

24. Pyle, S.I., H.C. Stuart, J. Cornoni, and R.B. Reed: Onsets, Completions and Spans of Osseous Stage of Development in Representative Bone Growth Centers of the Extremities (monograph), Soc. Res. Child Dev. 79, 1961.

25. Pyle, S.I.: A.M. Waterhouse, and W.W. Greulich: A Radiographic Standard of Reference for the Growing Hand and Wrist, Chicago, 1971, prepared for the U.S. National Health Examination Survey, distributed by Year Book Medical Publishers, Inc.

26. Roche, A.F., S.L. Eyman and G.H. Davila: Skeletal Age Prediction, J. Ped., 78:997-1003, 1971.

27. Rotch, T.M.: Chronologic and Anatomic Age in Early Life, J.A.M.A. 51:1197-1203, 1908.

28. Rowland, S.: A Series of Collotype Illustrations With Descriptive Text, Illustrating Applications of the New Photography to Medicine and Surgery, Archives of Clinical Skiagraphy, London, 1896, The Rebman Publishing Co., Ltd.

29. Seide, L.J.M.: The Relationship of Dentofacial Growth and Skeletal Maturation to Malocclusion, Am. J. Orthod. 45:801-816, 1959.

30. Solow, B.: The Pattern of Craniofacial Association; A Morphological and Methodological Correlation and Factor-analysis Study on Young Male Adults, Acta. Odontol. Scand. 24 (supp.): 46-174, 1966.

31. Stott, L.H.: The Longitudinal Study o Individual Development; Techniques for Appraising Developmental Status and Progress, Detroit, 1955, Merrill-Palmer School.

32. Subtelney, J.D.: Cephalometric Diagnosis, Growth, and Treatment; Something Old, Something New, Am. J. Orthod. 57262-286, 1970.

33. Webber, H.E.: A Practical Roentgenographic Densitometer, Am. J. Roentgenol. 46:104-108, July, 1941.

APPENDIX

CASE: B-105 MALE SKELETAL ADULT AGE:* = When the skeletal adulthood is reached on the hand-wrist radiograph.

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	CHRONOLOGICAL DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
57,5	65,5	118	50	12-18-44	17-2-26
58*	65*	119*	49,5*	4-8-41*	19-6-18*
57,5	65,5	119	50	5-19-49	21-7-29
58	65	118,5	51	7-6-51	23-9-16
58,5	65	119,5	51	2-20-56	28-5-0
58,5	65	120	51	4-11-68	40-6-21

OBLIQUE

S-Gn mm	Ar-Gn mm	Ba-Na mm
124,5	114	116,5
125,5*	114,5*	116,5*
125	114	116,5
125	115	116,5
126	115	116,5
127	116	117,5

HORIZONTAL

PNS-ANS mm	Go-Gn mm	S-N mm
66,5	80,5	78,5
66,5*	81,5*	78,5*
66,5	80,5	78,5
68	81,5	79
68	81,5	79
69	83	79,5

FRONTAL

Go-Go mm	ZyZy mm
97	135,5
98*	138*
99	139
98,5	138
99	139,5
99,5	139,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
82	76	+6	+8	-14,5	28	75	102,5	138
82*	76*	+6*	+7*	-14,5*	27*	74*	104,5*	138*
82	76,5	+55	+7	-14	27,5	73	103	140
82	76	+6	+8	-15	26	73,5	103,5	140
82	76	+6	+7,5	-14,5	27	73,5	104	140
82	76	+6	+7,5	-15	27	74	105	137,5

CASE: B-945 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
60,5	66,5	124	48,5	10-24-42	15-11-24
60*	67*	125*	51*	9-24-44	17-10-29*
60,5	67,5	125,5	51,5	10-25-46	19-11-25
60	70,5	126	48	6-19-51	24-7-19

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
128,5	115	115,5	58,5	75,5	76,5	105,5	136
131,5*	116,5*	117*	58*	75*	77,5*	107,5*	136,5*
131,5	118,5	117,5	60	76	77,5	108,5	137,5
131,5	118,5	118	60	80	77,5	110	138,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
83,5	77,5	+6	+13	-9	35	85	100	121
83,5*	78,5*	+5*	+12*	-8*	34*	87*	101*	117,5*
83	78	+5	+11	-9	34	86	99	121
79	76	+3	0	-5	26	77	88	146

CASE: B-1024 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54,5	73,5	126	49	4-20-40	17-0-28
55*	74*	128*	48*	4-3-42*	19-0-11*
55	74	127,5	51,5	4-23-46	23-0-28

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
132	119	109	55,5	81,5	73,5	107,5	139
134*	119*	110,5*	57,5*	82*	74,5*	109*	141,5*
134,5	121	110,5	58	81	74,5	110,5	142

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl °	Inter°
82	79	+3	+2	-7	33,5	89	89	129
82*	79*	+3*	+3,5*	-7*	34,5*	91*	92,5*	124*
83	80	+3	+3	-8	32	89	89	129

CASE: B-1668 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
47	70,5	118	44	12-12-33	17-10-20
48*	71*	118*	44,5*	12-20-35*	19-11-24*
47	71,5	118	47	8-25-39	23-7-30

OBLIQUE

S-Gn mm	Ar-Gn mm	Ba-Na mm
121,5	110,5	102
122*	111,5*	102*
122	113	103

HORIZONTAL

PNS-ANS mm	Go-Gn mm	S-N mm
52	77	67,5
52,5*	77*	67,5*
52	77	67,5

FRONTAL

Go-Go mm	ZyZy mm
97	133,5
98*	134,5*
100,5	135,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
78	75	+3	+1	-4	36	73	81	150
78*	75,5*	+2,5*	+1*	-5*	37*	73*	83*	150*
78	75,5	+2,5	+1	-4,5	36	74	81	151

CASE: B-1534 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	69,5	120	48	5-29-37	15-11-28
52,5*	70*	122*	52*	6-12-39*	18-0-11*
53	69,5	122	54	7-9-40	19-1-8
54	73	126	57,5	7-13-51	30-1-12

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
136	118	107,5	60	80	75	110	149,5
138*	123*	107*	61,5*	82*	76*	112,5*	151*
139	125	107	61,5	82	76	113	151,5
141,5	129	107	63,5	83	77	117	153

ANGULAR

SNA°	SNB °	ANB °	N.A.P°	NP-AB °	NS-Go.Gn°	1-Ba.Na°	T-Mpl °	Inter°
85	85	0	-3	-1,5	29	94	93	119
84*	85*	-1*	-4*	0*	28,5*	99*	92*	120*
85	85	0	-3,5	-2	27	99	91	123
85	85	0	-3,5	-1,5	29	90	89	131

CASE: B-1681 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
53	60,5	113	50	5-12-41	16-0-22
53*	61*	114*	49*	5-28-43*	18-1-8*
53,5	61	114,5	53	7-16-51	26-2-16

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122	112	112	59	79	76,5	98	137,5
123*	111*	112*	59,5*	80*	77*	98*	140*
126	117	112	59	80,5	77,5	102	143

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter°
79	77,5	+1,5	-2	-3	23,5	86,5	106	125
80*	78,5*	+1,5*	-2*	-3*	23*	86*	103*	128*
80	80	0	-5	-2,5	21,5	88	103	128

CASE: B-2032 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
53	73	125,5	53	21-10-45	18-0-15
53,5*	73,5*	126*	53,5*	12-28-46	20-0-3
53,5	74	126	53,5	2-21-48	21-1-26
53,5	74	126	53,5	7-3-51	24-6-8

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
132	111,5	106,5	57,5	75	72	100	140
133*	111,5*	106,5*	58*	74*	72*	101*	141,5*
133	111,5	106,5	57,5	73	72	101	141,5
132	111,5	106,5	57,5	73,5	73	101	141,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
84,5	80,5	+4	+3	-10	28,5	85	97	125
84,5*	80,5*	+4*	+5*	-10*	27,5*	85*	100*	120*
84,5	80,5	+4	+5	-10	26	86	96,5	125
84	79	+5	+5	-11	26	81	97	131

CASE: B-2209 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54	71,5	125	54,5	3-10-45	15-0-0
54,5*	74*	128,5*	54,5*	3-28-47*	17-0-18*
55	73	128	57,5	7-17-51	21-4-7

OBLIQUE

S-Gn mm	Ar-Gn mm	Ba-Na mm
135,5	118,5	116,5
138*	120*	116,5*
138	120,5	116,5

HORIZONTAL

PNS-ANS mm	Go-Gn mm	S-N mm
60,5	81,5	82
61*	84*	82*
63	82	82

FRONTAL

Go-Go mm	ZyZy mm
100,5	138
101*	139*
101	139,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mp1°	Inter°
80	78	+2	0	-4,5	24,5	82	98	135
80*	78*	+2*	0*	-5*	27*	83*	95*	135*
81	78,5	+2,5	0	-5	24	83	95	139

CASE: B-2216 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
55	70,5	123,5	52	3-7-41	15-0-1
55,5*	72*	126,5*	57,5*	3-3-43*	16-18-25*
57	76	131	59	5-31-51	25-2-25

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
124	107	108	58	69	73	95	131,5
127,5*	111,5*	109*	58*	70*	73,5*	97*	134*
128,5	112,5	109	58	71,5	74	98	134,5
130	114	109	58,5	70,5	74	98	137

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
79	75,5	+4,5	+8	-7	30,5	65	89	154
79,5*	75*	+4,5*	+8*	-7,5*	30*	64*	94*	150*
79	74,5	+4,5	+10	-7,5	31	66	94	147,5
79	75	+4	+6,5	-6	32	76	92	140

CASE: B-2425 MALE **SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
51,5	61,5	112	41,5	5-31-41	12-11-30
52,5*	63*	114*	46*	6-23-43*	15-0-22*
53,5	63	114,5	46	7-9-45	17-1-8
53	63	115	48,5	6-20-47	19-0-19

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
116,5	100,5	98	54,5	72	72	97	128,5
119*	104*	98*	54*	72,5*	73*	98*	130*
119,5	104	99	55	72,5	73	99	131
121	106,5	100	54,5	73	73	99	139

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
80	75	+5	+8	-8	32	85	102	123,5
80*	75*	+5*	+8*	-9*	31*	86,5*	101*	125*
80	75,5	+4,5	+7	-7	30	88	102,5	123,5
80	76	+4	+6	-7	30	90	99	125

CASE: B-2232 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
60,5	59	118	42	3-28-42	15-0-5
61*	59*	119,5*	43*	3-27-44*	17-0-4*
61	60	119,5	43	3-29-46	19-0-6

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
115	105,5	105,5	55	72,5	70	97,5	136
116*	105*	106*	55*	72*	70,5*	98*	136,5*
116	106	106,5	55	73	70	98,5	137

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
74	72	+2	+5	-5	42	80	83	141
74,5*	72*	+2,5*	+5*	-4*	41*	82*	87*	136*
74,5	71	+2,5	+5	-5	42	82	86	134,5

CASE: B-3194 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
58,5	69,5	127	48	5-9-42	18-0-2
58,5*	70,5*	128*	50*	5-4-44*	19-11-27*
59,5	71	130,5	53	6-26-51	27-1-19

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
133,5	120	109,5	58	84,5	75	101	140
135*	122*	109,5*	59*	84*	75*	102*	141,5*
136	123	110	59	83	75	103,5	143

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
80	77	+3	+2	-6	35	82	84	140
80*	77*	+3*	0*	-5*	35*	79*	84*	144*
79	76,5	+2,5	0	-5	36	78	83	147

CASE: B-3208 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
63	66	127,5	50,5	6-13-40	17-0-7
63*	67*	128,5*	52*	6-19-41*	18-0-13*
64	66	128	53	5-28-42	10-11-22
63,5	67	128,5	53	10-5-43	20-3-29

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	Zy-Zy mm
133,5	122	117	60,5	88,5	79,5	116,5	146
135*	123*	116,5*	61,5*	87,5*	79,5*	117*	147*
135,5	124	116	62,5	90	80	117,5	147,5
135	123	116	62	88,5	80	118	147,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
78	76	+2	0	-5,5	31	76	85	150,5
79*	77*	+2*	+1*	-5,5*	32*	80*	84*	148*
79	77	+2	-1	-6	30	80	84	150
79	77	+2	-1	-7	32	77	81	154

CASE: B-3408 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
55,5	70	124	46	5-2-40	15-0-1
56*	72*	127*	52*	5-1-42	17-0-0*
56	72	128	53	3-13-46	20-10-12

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
129,5	115,5	109	60	81	75	110,5	136,5
132*	119*	111*	61*	81*	76,5*	113*	139,5*
133	119	111,5	61	81	77	114,5	141

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn°	1-Ba.Na°	T-Mp1°	Inter°
78	77	+1	-2	-2	29	80	89	138
78*	77,5*	+0,5*	-3,5*	-2*	30*	82*	90*	138*
77	77	+0	-3,5	-2	31	83	89	138

CASE: B-3537 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
59	63	119	52	5-6-42	17-0-0
58*	63*	119*	53,5*	6-23-44*	19-1-17*
58	64	120	54	5-14-46	21-0 3
58	65	121,5	54,5	6-24-48	23-0-18

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
119,5	103,5	105,5	53,5	73	69,5	105,5	137,5
120,5*	105*	105,5*	54*	74*	70*	106*	139*
121	106	106	56	77	70	107,5	141
123	106,5	106	56	77	70	106,5	141

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
79,5	75	+4,5	+8	-10	21	71,5	110	134
78,5*	74,5*	+4*	+5,5*	-8,5*	24*	75*	110*	133,5*
78	74	+4	+5	-8	24	74,5	110	134
79	75	+4	+4	-7,5	23	77	110,5	131

CASE: B-3546 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	68	120	43	6-5-41	15-11-24
52,5*	68*	120*	45,5*	6-19-43*	18-0-7*
53	70,5	123	47	7-25-45	20-1-13

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
132	113	105	54,5	82,5	73	98,5	125
132*	115*	105*	57*	82*	73*	98,5*	125*
133	116	105	56,5	82	73	98,5	125

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter°
84,5	83	+1,5	0	+4	30	88	94	126
84,5*	82,5*	+2*	0*	+3,5*	28*	88*	94*	127,5*
85	83	+2	-1	+4	30	86	96	126,5

CASE: B-4141 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
59	75	134	55	11-11-57	16-4-9
61*	78*	139*	57*	9-1-60*	19-1-29*
60,5	80	140	60	9-6-62	21-2-4
61,5	82	142,5	61	1-21-69	27-6-19

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
144	130	117	60,5	95	76	106	146
148*	133*	117*	64*	98*	77*	108*	150*
148,5	134	117	64,5	98	77	110	150,5
151	136	118	64	98	77	111	152,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
81	80,5	+0,5	-6	-4	25	82	95	137,5
82*	81*	+1*	-4,5*	-5*	25*	84*	92*	139*
83	81	+2	-4	-5	24	84	91	141
83	81	+2	-4	-5	24	85,5	91	138

CASE: B-4361 MALE **SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
61,5	77	137	48	1-28-60	14-11-24
61,5*	77,5*	137,5*	51*	1-26-62*	16-11-5*
62,5	78	140	52,5	9-8-64	19-7-7
62,5	80	141	54	8-16-76	31-6-15

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
142	119	119	64,5	85	81	105,5	139
144,5*	121*	119*	64,5*	85*	82,5*	105,5*	141,5*
146,5	123,5	119	64,5	86,5	84	107	143
149	125	119	64,5	86,5	84	109	144

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
81	76	+5	+6	-11	33	82	97	124
81*	77*	+5*	+6*	-11*	31*	83*	96*	126*
81	77,5	+4,5	+4	-12,5	29,5	85	98	123
82	77	+5	+5	-11,5	30	81	98	125,5

CASE: B-112 FEMALE SKELETAL ADULT AGE:

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
53	64	116	46	10-1-41	13-7-9
53,5*	65,5*	118*	47*	2-24-43*	15-0-2*
54	66	119	49	3-2-45	17-0-10
54	67,5	120	49	4-3-47	19-1-11
53	68	120	50	4-15-49	21-1-23

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gr mm	S-N mm	Go-Go mm	ZyZy mm
115	105,5	105	53,5	72,5	69,5	88	126,5
117*	108*	105*	53,5*	73*	66,5*	89*	128*
117,5	109	105	54,5	73,5	66,5	89,5	128,5
118,5	109	105	55,5	73	66,5	89,5	128,5
118	109	105	55	73	66,5	89,5	128,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mp1°	Inter°
76,5	73,5	+3	+4	-5	35	81	102,5	126,5
76,5*	73,5*	+3*	+5*	-5*	36*	84,5*	104*	121*
77	73,5	+3,5	+5	-6,5	36	84,5	104,5	120,5
76,5	73	+3,5	+6	-6,5	36	85	107,5	119
76,5	73	+3,5	+5	-6	36,5	83	104	122

CASE: B-115 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
50	64	112	40,5	5-10-41	15-2-1
51*	65*	114*	44,5*	4-3-43*	17-0-25*
51	66,5	116	45,5	3-23-45	19-0-14

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
117	105	100	55	76,5	70	95	124
119,5*	106,5*	100*	55,5*	76*	70,5*	96,5*	125,5*
121	108	101	56	76,5	70,5	96,5	125

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
82,5	78	+4,5	-8	-8	32	80	101	129
82*	77,5*	+4,5*	-9*	-9*	32*	78*	97*	135*
82	77,5	+4,5	-8	-8	31	77	97,5	136

CASE: B-1074 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	74	126,5	48	4-25-41	16-0-4
52*	75*	126,5	48*	6-4-43*	18-1-14*
52	76	127	50	6-8-45	20-1-17
52	76	127	50	4-26-47	22-0-5

OBLIQUE		HORIZONTAL			FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
130	116,5	108,5	55,5	82,5	74,5	93	134,5
130*	116*	108*	55*	82,5*	75*	93*	134,5*
131	117	108	55	82,5	74	93	135
132	117	108,5	55	82,5	74	93	135,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Go.Gn °	Inter °
79	77	+2	+1	-5	34	86	94,5	127
79*	77*	+2*	0*	-4*	33*	86*	96*	128*
80	77	+3	+1	-6	33	87	95	126
80	77	+3	+3	-4,5	32,5	90	93	123

CASE: B-1208 FEMALE ADULT SKELETAL AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
48	65	113,5	45,5	1-18-41	12-11-28
48*	66*	114*	45*	1-22-43*	15-0-0*
50	65,5	115	46,5	2-24-45	17-0-0
50	68	117	52	3-28-50	22-1-0

OBLIQUE			HORIZONTAL		FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
121	110	107	56,5	78	70	92	126
122*	110*	107*	56,5*	80*	70*	92,5*	128,5*
125	112	107	55	81	71	93,5	128
124	114	107	57	82	71	93,5	128,5
124,5	116	107	56	81,5	70,5	94	129

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Go.Gn °	Inter°
80,5	79,5	1	-2	+2	30	91	94	129
81*	81*	0*	-4*	+1,5*	27*	93*	93*	129*
80	80	0	-4	+2	28,5	91	93	133
80	81	-1	-4	0	27,5	91	93	133
80	80	0	-4	+2	27	92	93	131

CASE: B-1212 FEMALE ADULT SKELETAL AGE

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
51	68	116	45	11-6-42	16-0-3
54*	68,5*	119*	48,5*	10-28-44*	18-0-0*
53,5	69,5	120	50	12-28-46	20-0-0

OBLIQUE		HORIZONTAL			FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
126	112	102	58	78	68,5	86,5	124
126,5*	112*	103*	58,5*	80*	68,5*	87,5*	125,5*
58,5	79	68,5	127,5	112,5	103	88	126,5

ANGULAR

SNA °	SNB°	ANB°	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Go.Gn °	Inter°
86,5	83	+3,5	+5	-7	26	82	89	140
85*	82*	+3*	+6*	-9*	29*	82*	92*	136*
85,5	82	+3,5	+4	-6,5	28	83	93	134

CASE: B-2034

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	63	112,5	45,5	1-10-42	14-0-8
52*	63*	113*	46*	1-15-44*	16-0-13*
52	63	113	48	1-4-46	18-0-2

OBLIQUE	HORIZONTAL				FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
117	103,5	102,5	54,5	70,5	66	93	127,5
118*	104*	103*	56*	70,5*	66,5*	93*	128*
119	104	103	56	70,5	67	94	128,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Go.Gn°	Inter°
80	78	+2	+4	-2,5	30	82,5	95	131
80*	78*	+2*	+3*	-2*	28,5*	87*	98*	125*
81	79	+2	+3	-3	28	87	101	124

CASE: B-1883 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
50	60	110	43,5	4-8-44	14-0-5
50,5*	60,5*	111*	44,5*	6-6-46*	16-2-3*
50,5	61,5	111	45,5	6-28-48	18-2-25
50,5	62	112	47	12-20-52	22-8-17
50,5	61	111,5	47	7-8-53	23-3-5

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
117,5	104	106	52	70	71	95,5	127
119*	105*	104*	52*	70,5*	71*	96,5*	128*
120	106	104,5	52,5	71	71	96	128
121	107,5	105	53	70,5	71	97	129
120	106	104	53,5	71	70,5	97,5	128,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Go.Gn°	Inter°
78	76,5	+1,5	-2	-5	32	85,5	88	134
78*	78*	0*	-5*	-3*	32*	85*	90*	133,5*
78	78	0	-3	-3	31	86	92	130
79	78	+1	-3	-4	31	87	94	128
80	79	+1	-2,5	-4	30	85	95	130

CASE: B-2097 FEMALE ADULT SKELETAL AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54	60	113,5	43	6-26-41	13-10-28
55,5*	60,5*	114*	43,5*	7-17-43*	16-0-0*
55	60	115	43	7-21-45	18-0-0
55,5	61	116	46	8-21-47	20-0-0

OBLIQUE			HORIZONTAL		FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122	108	101,5	49	79	67,5	104	135,5
124*	110*	104,5*	51*	80*	69,5*	106,5*	137,5*
123,5	112	103,5	51	82	69,5	106,5	137,5
124	112	104,5	50	81	69,5	107	138

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Go.Gn°	Inter°
82	80	+2	-2,5	-5	31	82	94	132
78,5*	77*	+1,5*	-3*	-5*	33*	86*	95*	126
81	79	+2	-2,5	-5	29,5	80	95	135
82	80	+2	-3	-5	30	82	95	134

CASE: B-2327 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54,5	74	128	45,5	4-26-43	14-11-30
53,5*	76*	129*	48*	5-14-45*	17-0-17*
54	74,5	128	48	4-27-46	18-0-0
54	75,5	128	48,5	6-18-48	20-1-21

OBLIQUE		HORIZONTAL			FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
124	110,5	101	54	76	67,5	96	130
126*	112*	100*	54*	76,5*	67,5*	97*	130,5*
125,5	112	101	55	77	67,5	97,5	131
125,5	112,5	100	55	77	67,5	97,5	131,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Go.Gn °	Inter °
75	71	+4	+4	-8	41	87,5	89	128
77,5*	73*	+4,5*	+6*	-8*	41*	87*	91*	126*
77	72	+5	+5	-10	40	85	90	129
78	73	+5	+5	-8	39	84	92,5	129

CASE: B-2328 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
55	70	124,5	45	4-26-43	14-11-30
55,5*	71*	126*	47,5*	5-14-45*	17-0-17*
55,5	71	126	45	4-27-46	18-0-0
55,5	71	126	46	6-17-48	20-1-20

OBLIQUE		HORIZONTAL			FRONTAL		
S-Gn mm	Ar-Gn mm	Ba-Nam m	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
126	112	101	57	77,5	68,5	101	131
127*	113*	103,5*	57*	78*	69,5*	101*	131*
128	114	103,5	57	80	69,5	101,5	131,5
128	114	104	57	80	69,5	102	132

ANGULAR

SNA °	SNB°	ANB °	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Go.Gn°	Inter°
77	74	+3	-1	-7	39	78	86	138
76*	74*	+2*	-2*	-6*	37*	81*	90*	133*
77	74	+3	-2	-7,5	37	81	90	133
77	74	+3	-2	-8	37	84	90	130

CASE: B-2440 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	71,5	123	43	6-24-39	15-0-12
52,5*	73*	125*	53,5*	6-12-41*	17-0-0*
52,5	73	124,5	44	8-21-43	19-2-9
52	74,5	126	44,5	6-20-46	22-0-8

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
125	112	108	55,5	78	73	99	127,5
126*	113*	109*	57*	78*	73*	99,5*	128,5*
126,5	113	108,5	57	78	73	100	128,5
127	113	108,5	57	78	73	100,5	129,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
78	75	+3	+3	-6	38	84	93,5	125
78*	74*	+4*	+4*	-7*	38*	81,5*	94*	127*
78	75	+3	+4	-7	37	85	97	121
78	74	+4	+4	-7	38	85	97	122

CASE: B-2517 FEMALE ADULT SKELETAL AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	56,5	108	47	4-8-38	14-11-30
53*	59*	108*	46*	4-13-40*	17-0-4*
53	57-	109	47,5	4-25-42	19-0-0
53	57,5	109	47	4-18-44	21-0-0
53	58	110	47	5-10-46	23-0-0

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	Zy-Zy mm
114,5	105,5	100	53	69	62,5	101	127
116*	104,5*	106*	52*	71*	66,5*	101,5*	129*
116	106	106	52,5	71	67,5	102	129,5
116,5	105,5	106,5	53	71	68	102	129,5
117	105,5	107	53,5	71	68	102	129,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
80	78	+2	0	-4	29,5	83,5	89,5	136
82*	80*	+2*	0*	-6*	27*	85*	91*	137,5*
81	79	+2	0	-4,5	28	85	92	137
81	79	+2	0	-6	28	84	91	137
81	79	+2	0	-5	28	83,5	93	135

CASE: B-2252 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54,5	76	127	51	12-22-42	15-2-18
54,5*	78*	129*	55,5*	12-29-45	18-2-27*
54,5	78	130	55,5	1-2-48	20-2-28
55	80	131	57	1-27-53	25-3-23

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
135,5	116,5	106	59,5	76,5	72,5	96	133,5
139*	120*	106*	62,5*	77*	74*	98*	136*
141	120	106	62	77	74	98	136,5
142	121,5	107,5	63	77,5	74	99	136

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
90	83	+7	+13	-10	32	77	94	130.5
90*	84*	+6*	+11*	-8,5*	29*	80*	94*	132,5*
90	84	+6	+12	-9,5	31	80	91	133,5
90	84	+6	+12	-9	30	79	93	133

CASE: B-2595 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
46,5	60	106	42	6-17-40	15-0-3
47*	61*	107,5*	44*	6-16-42*	17-0-2*
46,5	61,5	108	44	7-11-44	19-0-27

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
113	105,5	101	52,5	78,5	68,5	89	125,5
115*	107*	102*	54*	78,5*	68,5*	90*	127*
115,5	108	103,5	56	80	68,5	90	127,5

ANGULAR

SNA °	SNB °	ANB°	N.A.P°	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl °	Inter°
76	79	-3	-9	+2	28	98	85	132
76*	79*	-3*	-9,5*	+3*	28*	98*	85*	133,5*
77	79	-2	-8	+2	29	98	87,5	130

CASE: B-2770 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
60,5	74	133	53	2-9-35	14-11-30
60,5*	76,5*	135,5*	57*	2-13-37*	17-0-3*
61	76	135	58,5	12-28-38	18-10-18
61	76	136	58,5	12-30-40	20-10-20
61,5	76	136	58,5	1-10-42	21-11-0

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
132,5	122,5	113	60,5	84,5	76	109,5	141
142*	124,5*	114*	60,5*	84*	77*	110*	143*
142	125,5	114	61	83,5	76,5	110,5	144,5
143	126	113,5	60	83,5	76,5	110,5	144,5
142,5	126	113,5	60	83,5	76,5	111	145

ANGULAR

SNA °	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
83	80	+3	+4	-5,5	32	78	92	138
82,5*	79,5*	+3*	+5*	-5*	30*	77*	91*	142*
83	80	+3	+3	-4	28	79	92	141
83	80	+3	+3	-4	27	80	90	141
83	80	+3	+3	-4	30	77,5	90	142

CASE: B-2792 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
60,5	68	127	44	6-14-38	15-0-11
60*	70*	129*	49*	6-8-40*	17-0-5*
60,5	71,5	131	51,5	5-21-42	18-11-18

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
129	115	106	60	84	73,5	95	131,5
132*	119*	112*	60,5*	84*	75,5*	97*	134,5*
134	121,5	113	61	85	76	98,5	136

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Incer°
79	79	+4	+3,5	-8	36	69	86	150
79*	76*	+3*	+1*	-7*	36*	73,5*	81*	152*
78	76	+2	0	-5	34	74	82	154

CASE: B-3159 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
56,5	65	120	49	3-16-40	16-0-5
57*	67*	122*	53,5*	3-11-42*	18-0-0
57	67	122	55	3-31-44	20-0-20
56	68,5	123	52	6-22-51	27-3-11

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
126,5	117	112,5	59,5	80,5	68	103	137
129*	121*	112*	59,5*	81*	69*	105*	139,5*
129	122,5	112	61,5	81	69	106,5	140
129	120	112	61,5	81,5	68,5	107,5	141,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
84	80	+4	+55	-6	31	97	95	121
83*	80*	+3*	+4*	-6*	29*	96*	96,5*	120*
83	80	+3	+4	-5	30	95	95	127
83	80	+3	+4	-4	30	95	94	126

CASE: B-3189 MALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
57	63	118	47	5-11-38	15-0-0
58*	63*	119*	47*	5-16-40*	17-0-5*
58	63	120	50	5-11-42	19-0-0
58,5	63,5	120,5	52,5	6-18-51	28-1-7

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
126	114	107	59	78	69,5	107,5	134
129*	116*	108*	59*	80,5*	70*	110,5*	136,5*
131	119,5	108	60	81	71	111,5	138
131,5	120,5	108	62	81	71	111	138
133	122	108	64	81	71	112,5	139,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
84	80	+4	+5	-10	30	83	94	131
84,5*	81*	+3,5*	+1*	-8*	29*	87,5*	90*	132*
84	81	+3	+1	-7	28	90	89	132
85	82	+3	0	-7	26	92	89	133
85	82,5	+2,5	0	-5,5	24	90	90	135

CASE: B-4636 FEMALE **SKELETAL ADULT AGE:***

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54	67	119	48	7-31-67	14-7-2
55*	67,5*	120*	50*	1-24-69*	16-0-25*
55	69	121	51,5	1-8-75	22-0-9
55	69	121	51,5	10-3-75	22-9-4

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122	105	111	61	69	71,5	95,5	128
123,5*	106*	111,5*	61*	68*	71,5*	96,5*	129*
124	106,5	111,5	60,5	67,5	71,5	96,5	130
124	107	112	60,5	68	71,5	96,5	130

ANGULAR

SNA°	SNB°	ANB °	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl °	Inter°
79	75	+4	+6,5	-6,5	29	83,5	99	128
80*	76*	+4*	+6*	-5,5*	28*	84,5*	100*	126*
79	76	+3	+6	-4,5	27	83,5	103,5	124
79	76	+3	+5	-4,5	27	78	104	128

CASE: B-4323 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
48	64	111	38,5	4-14-49	12-3-28
48,5*	65*	113*	41,5*	9-15-51*	14-8-29*
49,5	66	116	41,5	4-4-53	16-3-18
48,5	66	115	41,5	7-13-55	18-7-27
48,5	67	115,5	43	9-10-58	21-9-24

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
116,5	99,5	101	52,5	73	70,5	90	120,5
119*	102*	101*	53*	73*	71,5*	90,5*	120*
120	103	101,5	53	74	71,5	91	120,5
120	103	101,5	53	74	71,5	91	120
120	103	102	53	74	71,5	91,5	120,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB °	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
79	77,5	+1,5	+3	-2	32,5	86,5	95	125
79*	78*	+1*	+1*	-1*	32*	87*	96,5*	124*
79	77,5	+1,5	+3	-2	32	86	96,5	126
79	78	+1	+2	-2	32,5	89	96	122
79	77,5	+1,5	+2,5	-2	32,5	90	97,5	120

CASE: B-3557 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
48,5	71	119	39	6-25-40	14-0-0
49,5*	73*	122*	39	6-19-42*	15-11-25*
50	73	123	41	6-16-44	17-11-21
50	73	123	41	6-27-46	20-0-2

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Nam m	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
120	106,5	102,5	51	75,5	69,5	94,5	122
122*	107*	102,5*	52*	76,5*	70*	94,5*	122,5*
123	109,5	103,5	52	78	70,5	94,5	122,5
123	109,5	103,5	52	78	70,5	95	122,5

ANGULAR

SNA °	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
73,5	73,5	0	-3	-1,5	38	80	96,5	127
74*	73,5*	+0,5*	-3*	-3,5*	39,5*	88*	97*	117*
74	73	+1	-2	-2,5	40	85	96	123
74	73,5	+0,5	-2	-2	40,5	86	99,5	118,5

CASE: B-3355 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
46	68	112	44,5	1-25-41	15-0-12
46*	68,5*	113*	43*	1-29-43*	17-0-16*
46,5	68	113	43	6-25-45	19-5-12
46,5	69	113	44	1-22-47	21-0-9

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
117,5	105,5	105,5	54,5	71,5	67	97,5	128
119*	105,5*	105,5*	55,5*	72*	67*	98,5*	128,5*
119	109,5	105,5	55	73	67	98,5	128
119	106,5	105,5	55	73,5	67,5	99	128,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
85	81	+4	+9	-6	34,5	97	103	108
86,5*	81*	+5,5*	+10,5*	-7*	34,5*	97*	101,5*	110*
85	80,5	+4,5	+8	-6	34	97	102,5	110
84,5	80	+4,5	+9	-6	34	94	102	114

CASE: B-3349 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
45,5	68	112,5	46	1-26-42	16-0-14
46*	68,5*	114*	47*	1-3-44*	17-11-0*
46	69	114	52	4-12-46	20-3-0

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122,5	110,5	105	55	73	72	94	135,5
124*	110,5*	105,5*	55*	73*	72*	94*	135,5*
124	115,5	106,5	55	73	73	94	135,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
80	81,5	-1,5	-3,5	+2	31,5	95	92	122
80*	81,5*	-1,5*	-5*	+3*	33*	93*	91*	124*
82	80	+2	-5	+2	31,5	94	90	124

CASE: B-3328 FEMALE SKELETAL ADULT AGE*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
46,5	64	109,5	43	12-27-43	18-0-13
46,5*	65*	110,5*	44,5*	12-27-45*	20-0-13*
46,5	65	110,5	44	12-26-47	22-0-12

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
121	109	98	54,5	81	66,5	89	125,5
123*	111*	98,5*	54,5*	81*	66,5*	89*	125,5*
122,5	110	98,5	54,5	81	67	89	126,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
80	82,5	-2,5	-10	+3,5	28	90	81	140
80*	83*	-3*	-10*	+3*	27,5*	89*	79*	144*
80	83	-3	-10	+2	27	93	100	138

CASE: B-3315 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
49,5	66	114	40	1-5-39	15-0-16
49,5*	67*	116*	41*	7-25-41*	17-7-5*
51	67	117	44	1-5-43	19-0-16
51	67	118	44,5	5-10-45	21-4-20

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
120,5	103	97,5	51,5	71,5	69,5	97,5	121
122*	105*	98*	52*	72,5*	69,5*	99*	122,5*
123	106	98	52	72	70	100	124
123	106,5	98	52	72	70	100	124,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
83,5	80,5	+3	+6,5	-5	33	83	93,5	129
83*	80*	+3*	+4*	-3*	33*	84*	91*	129*
82	80	+2	+3	-2,5	33	85	94	128
82,5	80	+2,5	+4	-2,5	35	85	93	126

CASE: B-3312 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
57,5	77	133	38	11-24-39	16-0-0
57,5*	79*	135*	40,5*	12-29-41*	18-1-5*
58	80	137	42	9-13-44	20-3-18

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
131,5	110	112	55	81	77	99,5	127,5
135*	112*	114,5*	55*	82*	79*	101,5*	129,5*
136	114	144,5	55,5	82	79	101	131

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na°	T-Mpl°	Inter°
78	74,5	+3,5	+8	-6	43	83	98	115
79*	74,5*	+4,5*	+7,5*	-7*	42*	82*	96*	119*
80	76	+4	+9	-7	43	83	97	117

CASE: B-2614 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
51,5	64	114,5	42,5	9-20-38	15-0-2
51,5*	64*	114,5*	41,5*	9-17-40*	16-11-30*
51,5	65	115	42,5	9-18-42	19-0-0
51,5	65,5	115	41,5	9-1-44	20-11-13
51,5	65,5	116	43	9-21-45	22-0-3

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
121	105	103,5	53,5	69,5	70,5	92	127,5
121*	105*	103,5*	53*	70,5*	70,5*	93*	127,5*
121	105,5	103,5	53	70	71	94	128
121	105	104	53	70,5	71	94	128,5
122	106	104,5	54	70,5	71,5	95	128,5

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl °	Inter°
81	77	+4	+4,5	-8	34	79	95	130
82*	77*	+5*	+4,5*	-10*	34*	77*	95*	133*
82	77	+5	+5	-9	35	79	94	131
81	77	+4	+5	-9	36	79	92	131
81,5	77	+4,5	+5	-9	35	79	95	130

CASE: B-2514 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
51	62	112	34,5	1-6-39	15-0-4
51*	62*	113*	37*	1-4-41*	17-0-2*
51,5	63	113,5	39,5	1-17-44	20-0-15
53	63	115	39	2-22-57	33-1-20

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
119	98	97,5	49	72	65	94	130
119,5*	100,5*	97,5*	51,5*	73*	65*	95*	131*
120,5	102,5	98,5	51,5	72,5	66	95	131,5
121	101,5	100,5	51,5	72,5	66	95	132

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
85	81	+4	+5	-7	30	78	94	132
85*	81*	+4*	+5*	-6*	30*	80*	95*	129*
83	80,5	+2,5	+4,5	-4	31	81	95	128
82	79	+3	+3	-4	31,5	82	95	126

CASE: B-2627 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
54	62	115	44	1-10-44	11-6-4
54,5*	64*	117*	46*	9-7-45*	13-2-1*
55	65	120	47	2-13-48	15-7-7
55	66	121	47,5	9-11-50	18-2-2

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Nam m	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122	105	104	52,5	71	69	99,5	127
123*	106*	104*	52*	71*	69*	102*	129*
125,5	108	104	53	71	69	102	129,5
126	108,5	104	53	71	69	103	130,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter°
80	77,5	+2,5	0	-6	34	85	91	128
79*	77*	+2*	0*	-5*	35*	83*	86*	135*
79	77	+2	-1	-5	35	83	88	133
79	77	+2	-1	-6	35	85	90	128

CASE: B-2655 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
56	73	127	44,5	3-27-41	15-11-27
55*	74,5*	128*	45*	8-24-43*	18-4-24*
55	73	128	45	3-31-45	20-0-0
56	75	130	47	3-24-47	21-11-23

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
126	112	103	56,5	76,5	67	98,5	134
127*	112,5*	102*	56*	77*	67*	99*	135*
127	112	103	56	77	67	99,5	135
129	115	103	56	77	67	99	136

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter°
78	75	+3	+5	-2	45	98	87	114
78*	76*	+2*	+3*	-2*	45*	98*	88*	114*
78	75,5	+2,5	+3	-2,5	45	99	88	112
76,5	74	+2,5	+3	-2,5	45	97	86	116,5

CASE: B-2702 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
57	61	116	50	8-9-44	15-1-28
57,5*	61*	117,5*	53*	7-2-46*	17-0-21*
58	62	117,5	52	7-7-48	19-0-26
57,5	62	118	51	6-27-49	20-0-16

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
119	106,5	102	56	74	67	94	130
121*	109*	102,5*	57,5*	76*	67,5*	94*	131*
121	109	102,5	57,5	76,5	67	94	131,5
121,5	108,5	102,5	58,5	76	67	95,5	132,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
80	77	+3	+2,5	-9	27	73	97,5	144
81*	78*	+3*	+1*	-7,5*	25*	77*	100*	140*
81	78	+3	+1	-7,5	25	77	99	140
80	77	+3	+1	-7,5	26	77	98,5	141

CASE: B-3047 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
55,5	63	116	43	3-23-46	12-0-8
55,5*	64*	117*	43,5*	3-29-48*	14-0-14*
55,5	64,5	117	46	3-18-50	16-0-3
57	65	119	46	4-12-52	18-0-27
57,5	65	119	46	4-6-53	19-0-21

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	3a-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
120,5	107,5	110	60,5	77	75,5	98,5	127,5
122*	109*	110,5*	62,5*	78*	76*	100*	130*
122,5	110	110	63	79	76	101	130,5
123	110,5	110,5	63	79	77	101	131
123	110	110,5	63	78,5	76,5	101,5	131,5

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter°
80	77,5	+2,5	+4,5	-4	30	95	102	115
81*	78*	+3*	+4,5*	-4*	29*	95*	103*	114*
80	78	+2	+4	-3,5	29	93	105	116
80	78	+2	+4	-3	30	95	105,5	113
80	78	+2	+4	-3	28	94	104	117

CASE: B-3195 FEMALE ADULT SKELETAL AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52,5	58	110,5	40	5-13-38	14-0-4
53*	60*	112*	41,5*	5-6-40	16-0-0
53,5	60	112,5	42,5	6-9-42	18-0-0
53	61	113	44	7-13-44	20-0-0
52,5	62	113,5	44,5	5-22-46	22-0-0

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
119	105	105,5	54	74	119	92	122,5
120,5*	105*	107*	54,5*	77*	120,5*	93*	123,5*
121	107,5	107	54,5	77	121	94	125
121,5	112	107	54,5	77	121,5	94	125
123	113,5	108	54,5	77	123	94,5	125

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
82	80	+2	+1	-4	30	81	90	136
82*	80*	+2*	+1*	-4*	30,5*	82*	91*	137*
82	80	+2	+1	-3	30,5	85	92	135
81	79	+2	+2	-4	31	85	91	135
81	79	+2	+4	-4	31	85	91	134

CASE: B-3197 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
48	57	105	48	5-11-37	11-11-27
49*	59,5*	108*	45*	5-15-39*	14-0-1*
48	60	108,5	45	5-16-41	16-0-2
49	60,5	109	46	6-5-44	19-0-21
48	61	109	45	6-6-46	21-0-22

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
109	95	96,5	48,5	68	62,5	94	134
114*	100,5*	97,5*	50*	72,5*	63*	98*	138*
115,5	100,5	98,5	50,5	72,5	63,5	99	140
115,5	101	99	51	73	64	99,5	140,5
115,5	101	99,5	52	74,5	64	100	140,5

ANGULAR

SNA°	SNB°	ANB °	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na °	T-Mpl °	Inter°
79	78	+1	-3	-2	29,5	76,5	83	151,5
80*	80*	0*	-4*	-3*	25*	78*	83,5*	151,5*
80,5	81	-0.5	-7	-2	23,5	78	80	155
78,5	79,5	-1	-7	-2	24	78	82	155
80	80,5	-0,5	-8	-2	24	78	79	155,5

CASE: B-3234 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
51	61	112	43	6-21-37	13-10-27
53*	63*	115*	45,5*	7-28-39*	16-0-3*
52,5	63	115	45,5	7-17-41	18-0-0
51	64,5	114	46	8-28-43	20-0-0
51	63,5	115	48	7-25-45	22-0-0
51	66	115	48	9-9-47	24-0-0

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
122,5	113,5	103	53	73	73	93	133,5
123,5*	110*	105*	53*	76,5*	73*	94*	134*
124	111	104	53	78	73	94,5	135
125	112	104	55,5	78	74	95	136
126	112	104	57,5	79,5	74	95	135,5
126	112	104	58,5	78	74	95,5	136

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
81,5	79,5	+2	+1	-4	30,5	82	90	136,5
79,5*	78*	+1,5*	0*	-2*	30,5*	81*	92*	135*
79,5	78	+1,5	0	-3	33	80	89	138
81,5	80	+1,5	0	-3	30,5	81	87	140
81	79	+2	0	-4,5	30	80	90	140
81,5	80	+1,5	0	-4	30	82	89	139

CASE: B-3241 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
52	70	122	42	9-22-38	14-0-20
52,5*	72*	125*	43*	10-5-40*	16-1-3*
52	73	125,5	43	1-8-43	18-4-6
53	73	126,5	43	12-29-44	20-3-27

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
125	106	99,5	50	76	66,5	95,5	124
128*	108*	100*	50,5*	78*	66,5*	97,5*	125,5*
129	108	100	50,5	78,5	67	98,5	127
130	108	100	50,5	78	67	98,5	127

ANGULAR

SNA °	SNB °	ANB °	N.A.P °	NP-AB °	NS-Go.Gn °	1-Ba.Na °	T-Mpl °	Inter °
74,5	76	-1,5	-10	-1	34	84	89	130
74*	76*	-2*	-11,5*	-1*	34*	86*	90*	127*
74	76	-2	-10	-2	33	85	91	127
74	76	-2	-10	-1,5	34	86,5	90	127

CASE: B-3269 FEMALE SKELETAL ADULT AGE:*

VERTICAL

Na-ANS mm	ANS-Me mm	Na-Me mm	Ar-Go mm	DATE Mo-D-Y	CHRONOLOGICAL AGE Y-Mo-D
47,5	64,5	111,5	50	10-18-38	15-0-7
48*	65,5*	113*	52,5*	10-11-40*	16-11-24*
48	68	114,5	50,5	2-20-43	19-4-0
48	67	113,5	47,5	9-1-44	20-7-15

OBLIQUE			HORIZONTAL			FRONTAL	
S-Gn mm	Ar-Gn mm	Ba-Na mm	PNS-ANS mm	Go-Gn mm	S-N mm	Go-Go mm	ZyZy mm
120	108	99,5	53	71	65,5	97	135
121,5*	112*	100,5*	53,5*	73*	66,5*	97,5*	135,5*
122	110,5	100	54,5	73,5	66,5	98,5	136,5
123,5	108,5	100	54	73,5	66,5	98	136

ANGULAR

SNA°	SNB°	ANB°	N.A.P°	NP-AB°	NS-Go.Gn°	1-Ba.Na°	T-Mpl°	Inter°
81	80,5	+0,5	-3	+2	29	89	96	125
81,5*	81*	+0,5*	-3,5*	+2*	29*	87*	93*	129*
81	80,5	+0,5	-3,5	+2,5	28	91	94	125
83,5	82	+1,5	-1,5	+3	27	92	97	121

GLOSSARY OF

ANATOMICAL LANDMARKS

S - (Sella Tuccica) - The hypophyseal or pituitary fossa of the sphenoid bone lodging the pituitary body. The landmark "S", is the center of sella as seen in the lateral roentgenogram and located by inspection.

Na - (Nasion) - The craniometric point where the midsagittal plane intersects the most anterior point of the nasofrontal suture, the anterior termination of the bottom plane.

Ba - (Basion) - The point where the median sagittal plane of the skull intersects the lowest point on the anterior margin of the foramen magnum.

Az - (Bjork Articulare) - The intersection of the image of the posterior border of the ramus with the base of the occipital bone.

A.N.S. - (Anterior Nasal Spine) - A sharp, median process formed by the forward prolongation of the two maxillae at the lower margin of the anterior aperture of the nose.

P.N.S. - (Posterior Nasal Spine) - A process formed by the united, projecting medial ends of the posterior borders of the two palatine bones.

Go - (Gonion) - The external angle of the mandible, located on the lateral roentgenogram by bisecting the angle formed by tangents to the posterior border of the ramus and the inferior border of the mandible.

Gn - (Gnathion) - The lowest, most anterior midline point on the symphysis of the mandible.

Pog - (Pogonion) - The most anterior point on the symphysis of the mandible in the median plane.

Point "A" - (Subspinale) - That point is located in the median sagittal plane where the lower front edge of the anterior nasal spine meets the front wall of the maxillary alveolar process (Downs).

Point "B" - (Supramentale) - The deepest midline point on the mandible between infradentale and pogonion.

Me - (Menton) - The most inferior point on the symphysis of the mandible in the median plane. Seen in the lateral roentgenogram as the most inferior point on the symphyseal outline.

Zy - (Zygion) - A craiometric point at either end of the greater bizygomatic diameter or width on the outer surface of the zygomatic arch.

Is - (Incision Superius) - Tip of the crown of the most anterior maxillary central incisor.

ii - (Incision Inferius) - Tip of the crown of the most anterior mandibular central incisor.

U.I.A. - (Upper Incisor Apex) - Apex of the most anterior maxillary incisor.

L.I.A. - (Lower Incisor Apex) - Apex of the most anterior mandibular incisor.

I.L.S. - (Axis of Maxillary Incisor) - Line from incision superius (IS), through the apex.

I.L.i. - (Axis of mandibular incisor) - Line from incision inferius (ii), through the apex.

A-B Line - Relation of A Point (infraspinale) to B Point (supramentale). It represents the anterior points of the basal arches of the jaws, and is used to determine the anteroposterior relation of the jaws, to one another, and to the facial line.

N-Pog - (Facial Line) - A line from masion to pogonion.

LINEAR MEASUREMENTS

1. VERTICAL MEASUREMENTS

Na-ANS - (Nasion-Anterior Nasal Spine) = Upper anterior facial height.

ANS-Me - (Anterior Nasal Spine - Menton) = Lower anterior facial height.

Na-Me - (Nasion-Menton) = Anterior facial height.

Az-Go - (Articulare-Gonion) = Mandibular ramus height.

2. HORIZONTAL MEASUREMENTS

PNS-ANS - (Posterior Nasal Spine - Anterior Nasal Spine) = Palatal plane - Palatal length.

Go-Gn - (Gonion - Gnathion) = Mandibular plane - Mandibular plane - Mandibular body length.

S-N - (Sella-Nasion) = It denotes the anterior portion of the cranial base. Length of anterior cranial base.

3. OBLIQUE MEASUREMENTS

S-Gn - (Sella-Gnathioz or Y-axis) = Expression of the direction of this growth, of the face. (Downs, 1949)

Az-Gn - (Articulare-Gnathion) = Mandibular length.

Ba-Na - (Basion-Nasion) = Length of the cranial base.

4. FRONTAL MEASUREMENTS

Go-Go - (Gonion-Gonion) = Bigonial width.

Zy-Zy - (Zygion-Zygion) = Bizygomatic width.

ANGULAR MEASUREMENTS

SNA - (Sella-Nasion-A Point) = It represents the anteroposterior relationship of the maxillary basal arch to the anterior cranial base.

SNB - (Sella-Nasion-B Point) = Shows the anterior limit of the mandibular basal arch in relation to the anterior cranial base.

ANB - (A Point-Nasion-B Point) = It indicates the anteroposterior relationship of maxillary and mandibular basal arches to the anterior cranial base.

N-A-P - (Nasion-A Point-Pogonior or Angle of Convexity) = Measure of the protrusion of the maxillary part of the face to the total profile (Downs, 1949).

NP-AB - (Na-Pog-A Point-B Point or AB plane to the facial plane) = Measure of the relation of the anterior limit of the denture bases to each other and to the profile (Downs, 1949)

NS-GoGn - (Mandibular Plane Angle) = Measures the angulation of the mandibular corpus to the anterior cranial base.

$\underline{I}$-BaNa - (Axis of Maxillary Incisor - BaNa Line) = Axial inclination of the maxillary incisors to the cranial base.

$\overline{I}$-GoGn - (Axis of Mandibular Incisor-GoGn(Mandibular Plane) = Axial inclination of the mandibular incisor in relation to the mandibular plane or the measure of the procumbency of the mandibular incisors to the mandibular plane.

Interincisal Angle - (Angle formed from the intersection of the axis of mandibular incisor and the axis of the maxillary incisor) = Angulation of the upper and lower incisors to each other and to the face.

FIGURE 1

Anatomical landmarks in the lateral cephalogram

Bo
Ba
Ar
Go
PNS
S
LIA
Me
Gn
Pog
B
Is
ii
A
ANS
UIA
Na

FIGURE 2

Anatomical landmarks in the frontal cephalogram

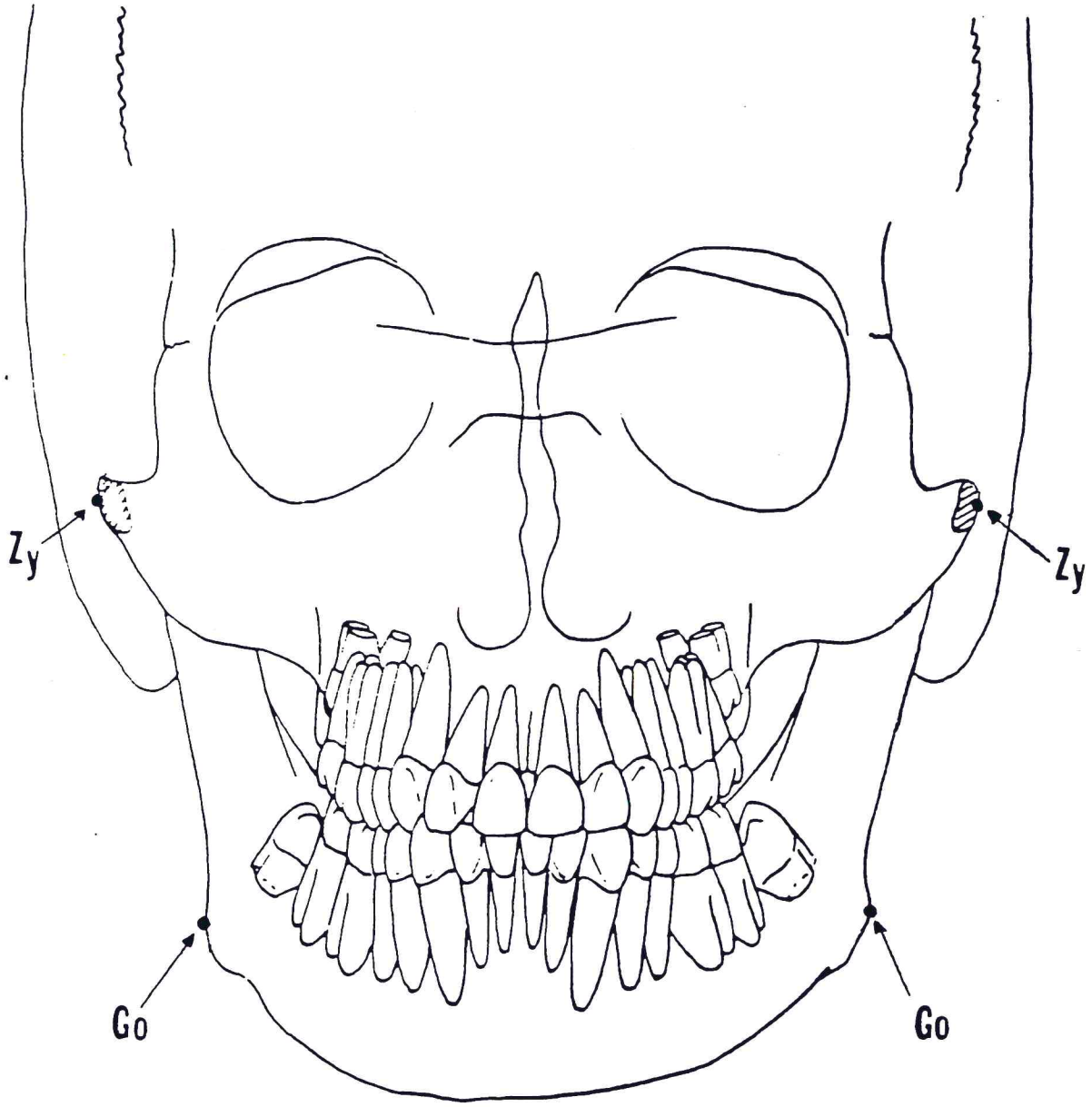

Zy
Zy
Go
Go

FIGURE 3

Linear, vertical measurements

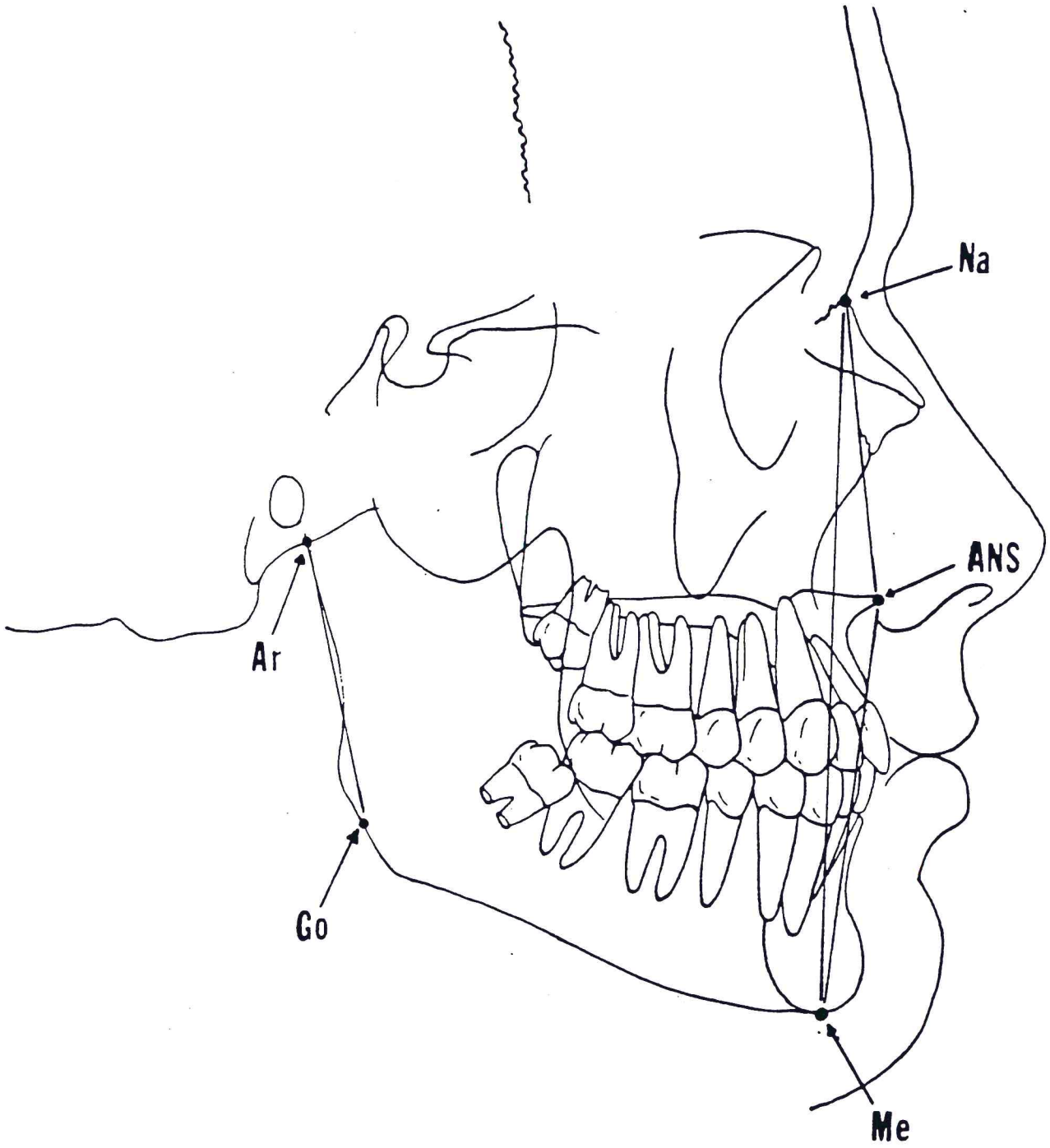

Na
ANS
Ar
Go
Me

FIGURE 4

Linear, horizontal measurements

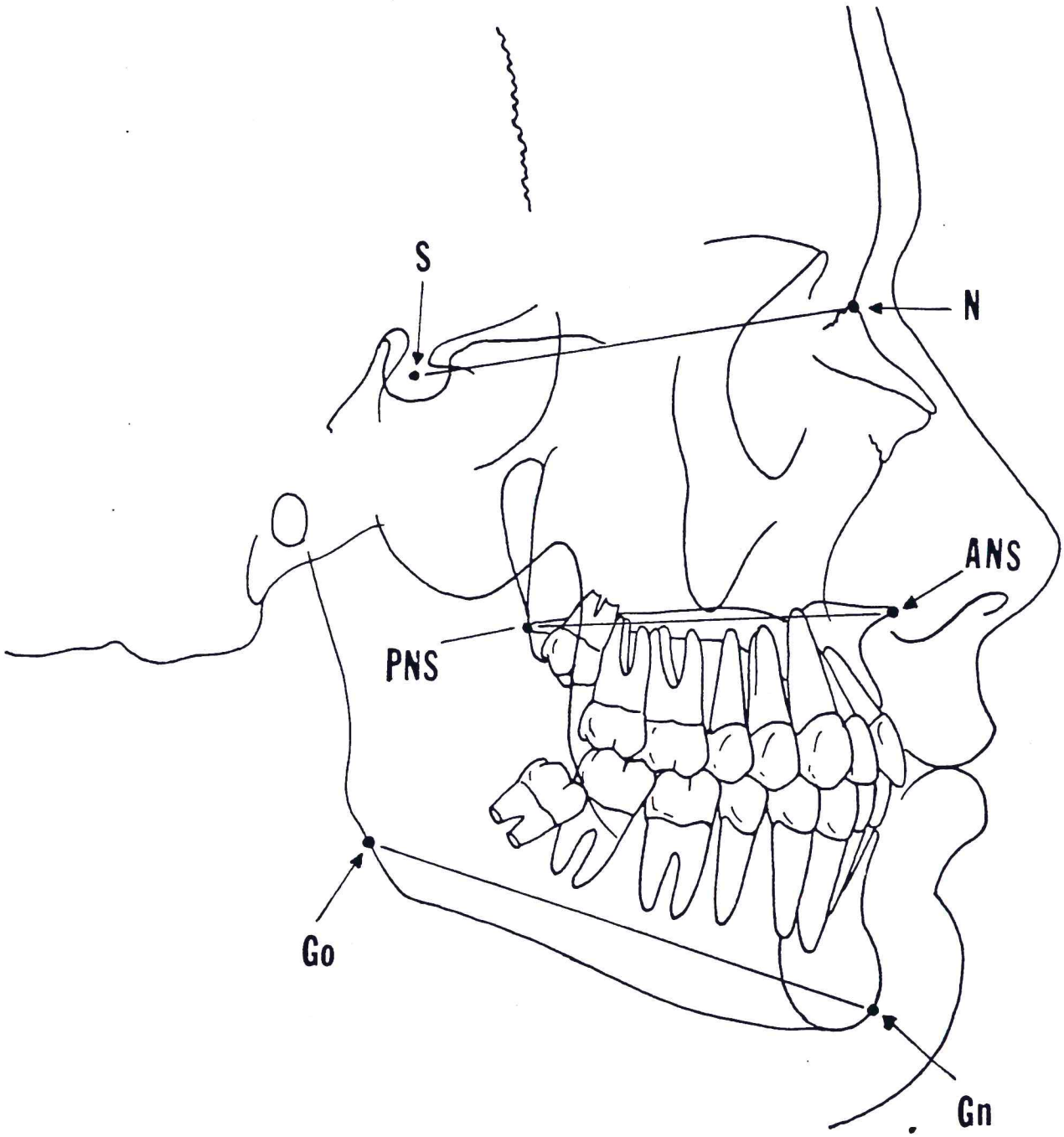

S
N
ANS
PNS
Go
Gn

FIGURE 5

Linear, oblique measurements

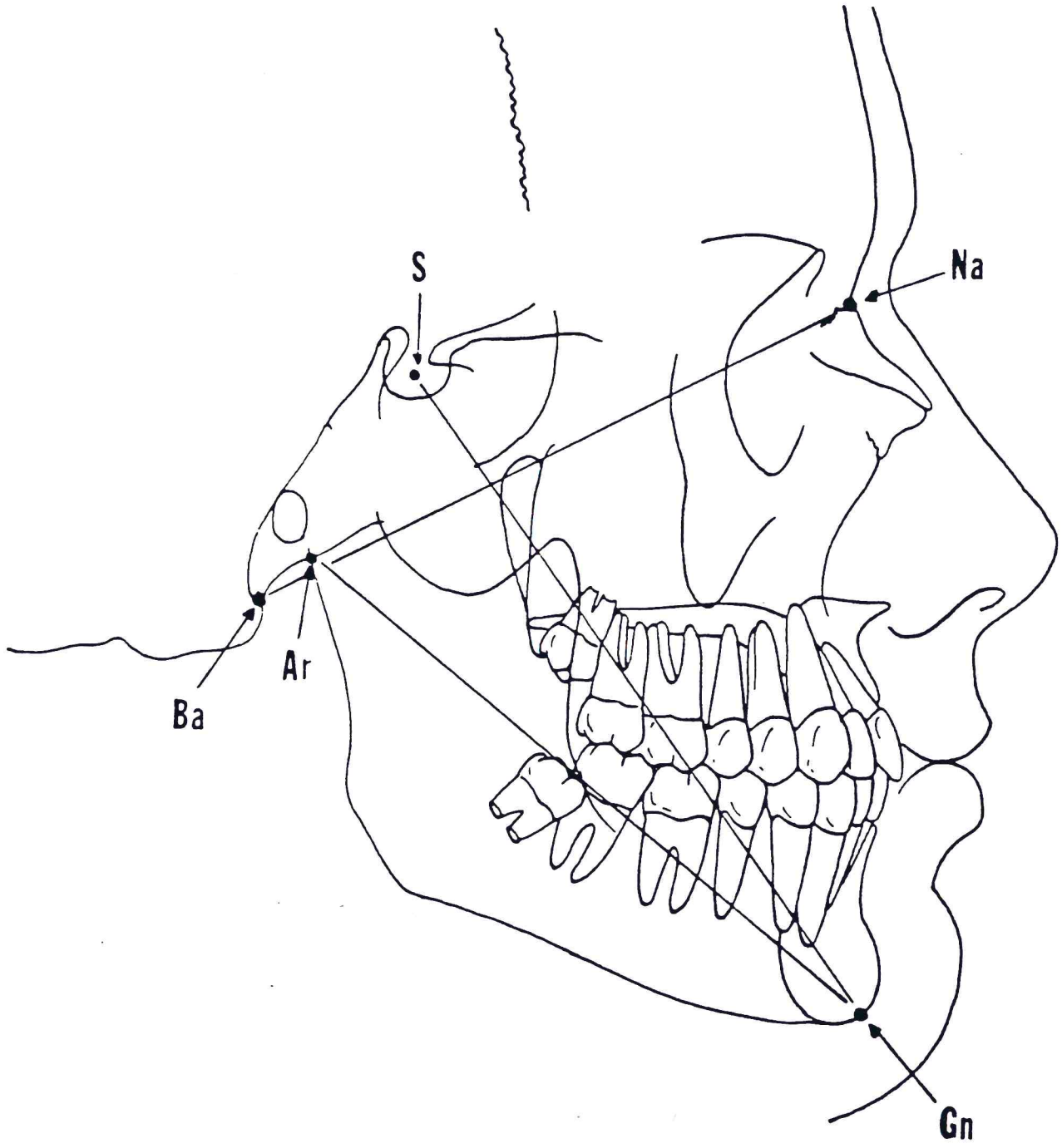

S
Na
Ar
Ba
Gn

FIGURE 6

Linear, frontal measurements

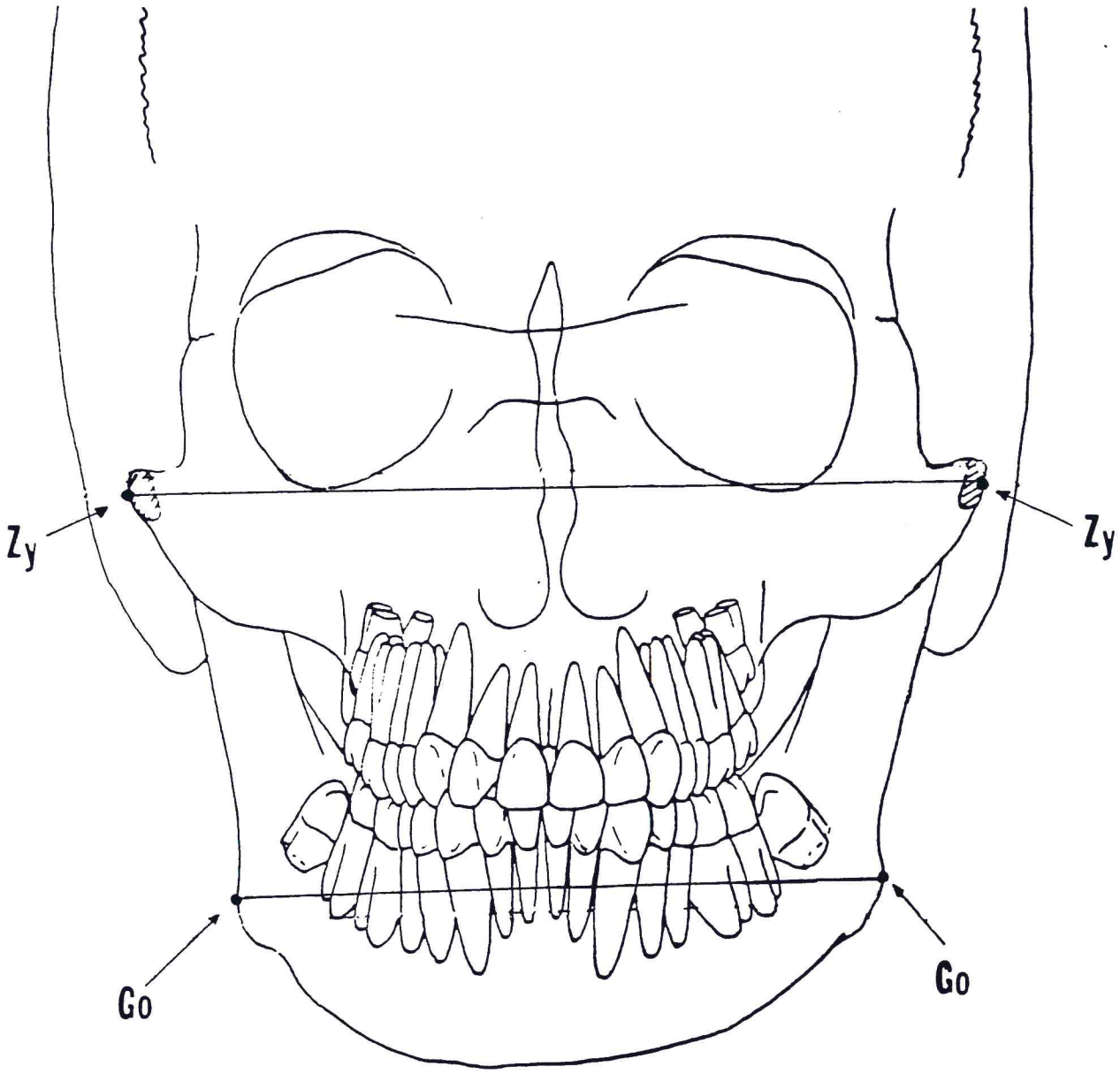

Zy
Zy
Go
Go

FIGURE 7

Angular measurements

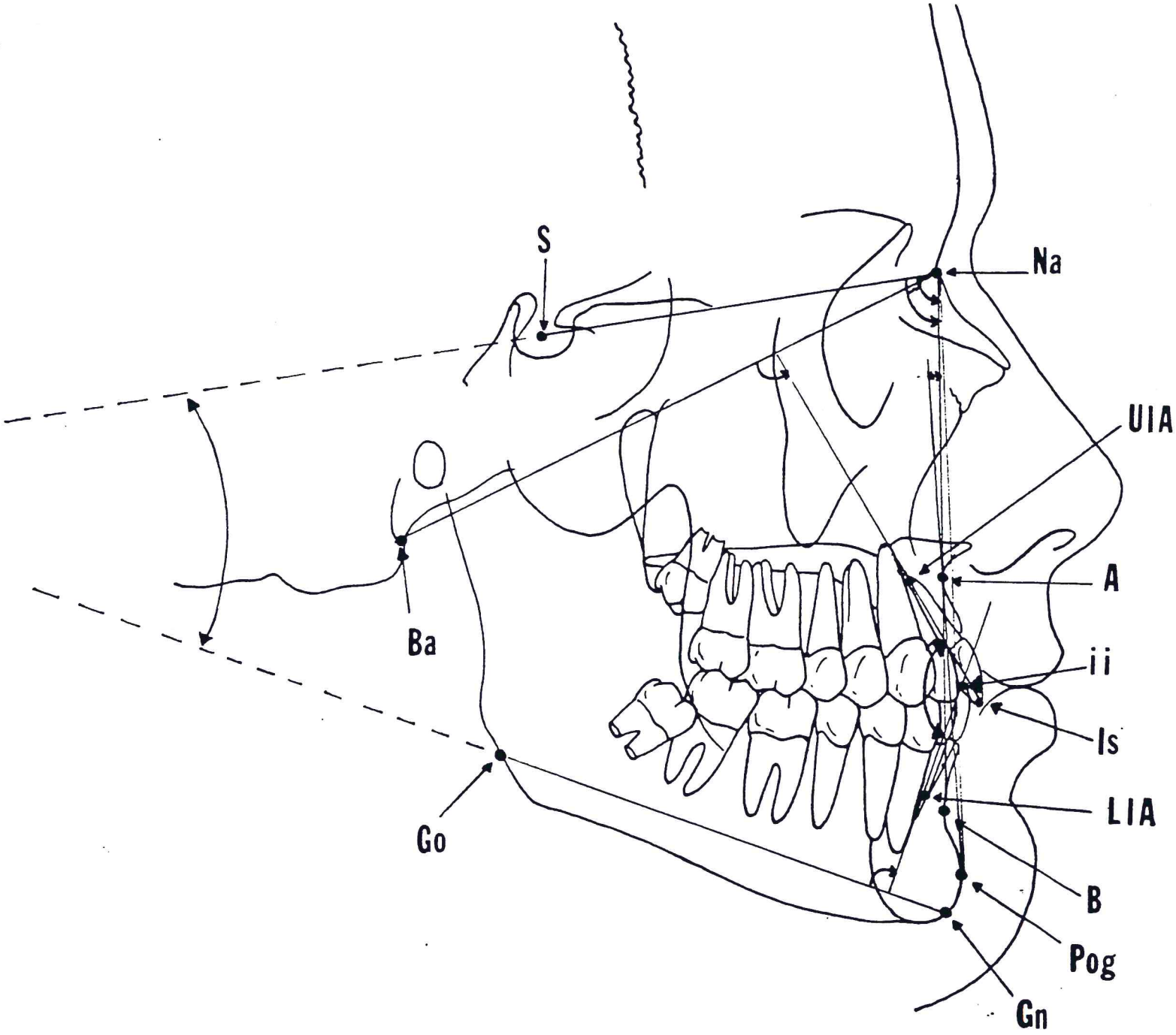
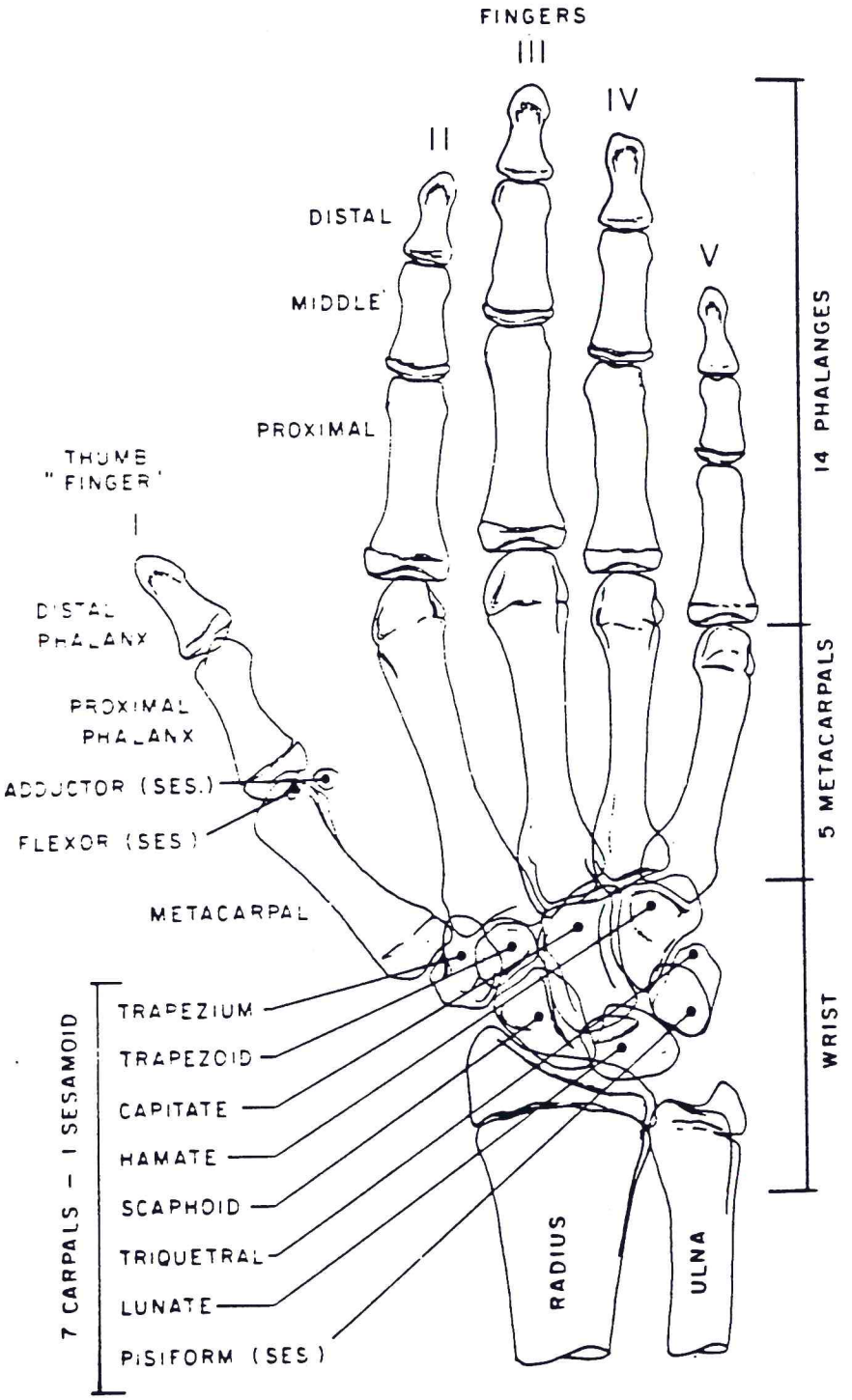

S
Na
UIA
A
Ba
ii
Is
LIA
Go
B
Pog
Gn

FIGURE 8

Diagramatic outline of the hand and wrist



Diagrammatic outline of the hand and wrist, indicating nomenclature and structural grouping.

FIGURE 9

Superimposition from 2 years before adulthood to adulthood for male patient (B-2770)

_____ - Before

..... - After



FIGURE 10

Superimposition from adulthood to 2 years after adulthood for male patient (B-2770)



FIGURE 11

Superimposition from 2 years before adulthood to adulthood, for female patient (B- 3791)



FIGURE 12

Superimposition from adulthood to 2 years after adulthood, for female patient (B-3791)

